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By K.E. Andersen

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INSTITUTE OF FISHERY TECHNOLOGY RESEARCH

The ensilage of capelin for fish feed as an alternative to freezing -An economic analysis

Report dated 25 April 1984, by
Knut Eirik Andersen, Economics/ Processing Department
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ABSTRACT

This report presents a financial analysis of using capelin ensilage as fish feed as an alternative for frozen capelin. The analysis includes technological, biological and financial data. A full cost estimation is used to determine the maximum price that can be paid for capelin to be used for ensilage and possibly heat treatment. The profitability of investments in heat treatment equipment is also considered. Such equipment reduces the requirement for binding agent in the ensilage from 50% to 15%. An alternative method using lactic acid is also evaluated, and the maximum profitable price for lactic acid bacteria is calculated. Finally, a sensitivity analysis is carried out, involving changes in some of the most fundamental requirements underpinning the analysis.

KEYWORDS: Economics, ensilage, fish farming

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SUMMARY

Organic acids such as propionic acid and formic acid have proven to be particularly well suited for preservation of small fishes and waste from the fish processing industry. Such a process and its product is called ensilage and one can today see an increasing number of ensilage facilities aboard fishing vessels.

Whether the ensilage process involves the whole fish (such as capelin) or only waste, the digestive enzymes are naturally present and work under suitable conditions in the appropriate pH-range, and the material will be completely dissolved. However, the nutritional value is maintained.

This report concerns the use of ensilage from capelin as an alternative to frozen capelin. Other types of feed are not discussed. Frozen capelin costs approximately kr 1.50 per kg. To obtain a suitable consistency, it must be mixed with a binding agent; in the order of 10%. However, capelin ensilage requires some 50% binding agent for the feed to be satisfactory. Thus, the cost of the binding agent is significant. To obtain a realistic picture of the costs for the two types of feed, it is necessary to consider the costs related to the investment required for feed production, the operating costs, the extent of wasted feed and the energy content in capelin. The two latter factors in part determine the feed factor (the amount of feed required to produce 1 kg of salmon).

In the analysis, it was assumed that the feed losses amounted to 40% for acid feed and 48% for liquid feed. This, in combination with an average energy content in capelin of 6.8 MJ convertible energy per kg, provides feed factors

of 2.4 for acid feed and 3.5 for liquid feed. The calculations were done on the basis of growth in the fish raised.

Most of the calculations were made for a breeding facility of 8 000 m^3, while some calculations were made for smaller facilities (3 000 m^3).

A full cost analysis for the feed production at a breeding facility shows that the operator will hardly pay more than kr 0.85 per kg of delivered ensilage. The reason for this is the binding agent cost which is quite large when ensilage is used for acid feed.

An ensilage facility which must deliver to a large number of operators, should therefore not exceed this price. Full cost estimates are required to solve the first part of the problem:
-What is the most an ensilage facility should pay for capelin?

The Hamjern ensilage facility produces 4 600 tons of ensilage per year and distributes the finished product by boat. Thus, the production of capelin ensilage is balanced on the boundary of profitability: the operator should be able to pay some kr 0.43 per kg of fresh capelin. This, however, supposes that a complete facility is built from the outset, including unloading facilities, as well as intermediate and long term storage tanks.

Herring oil or meal factories already possess both unloading facilities and storage tanks. Provided that the ensilage production can be combined with other operations, the costs for facilities and tanks can thus be reduced to the extent that ensilage production becomes profitable. If, in addition, it is possible to obtain capelin waste as raw material for the production, the conditions are very favourable. Capelin waste is today sold for some kr 0.20 per kg.

However, it is possible to reduce the amount of binding agent required. It may be reduced from 50% to 15% if the ensilage is heat-treated after the addition of acid. Heating to 80-90 degrees C will make the enzymes completely inactive and stop autolysis. The consistency of the ensilage becomes completely different while the process continues in the normal manner.

It is also possible to add less acid, heat-treat the ensilage, and then add lactic acid bacteria, which during the production of lactic acid further reduce the pH. The lactic acid bacteria depend on sugar as a source of nourishment, and molasses must therefore be added to the acid in a concentration of 1.5%. The amount of acid in the ensilage can thus be reduced. The lactic acid bacteria do not lead to degradation or putrification of the fish but act only as a preservation agent.

If an operator wishes to use one of the two types of heat-treated ensilage, this means that the feed factor will be 3.0, with the consequences this will have on the cost picture. Even if slightly more binding agent is required than for frozen capelin, the operator will at least be as well off, since he pays kr 1.55 per kg for heat-treated ensilage.

To produce heat-treated ensilage, it is necessary to invest in heat treatment equipment. The Landteknikk Company provides a so-called "Flow-therm" process requiring equipment at a cost of some 1.3 million kr, installed at Tromso. The plan is to connect the ensilage unit from the Hamjern Company to this equipment. The processing equipment at the latter company has required an investment of over kr 200 000.

If lactic acid fermentation is instead desired, the Stord Bartz Company can deliver a complete unit for ensilage and heat treatment. It costs some kr 816 000. In addition, the usual equipment is required for unloading, intermediate storage and storage tanks.

Since the admixture of capelin ensilage in these processes, by comparison to normal ensilage, will increase from 50% to 85% and since the feed factor rises from 2.4 to 3.0, it will be appropriate to here operate with a produced quantity of 10 200 tons annually in order to make comparisons possible. This is a significant amount but not unrealistic in the long term.

In spite of significantly increased investments, it would be possible, at a selling price of kr 1.55 per kg for heat-treated ensilage, to pay kr 1.16 per kg for acid ensilage capelin. For lactic acid fermentation, it would be possible to pay the same price and up to kr 70 for lactic acid bacteria per ton of ensilage.

Given the pre-requisites presented in this analysis, it appears that production of heat-treated ensilage of capelin could be very profitable. Even if a profit margin of some 20% is used, it is still possible to pay a price for fresh capelin which is clearly above the current market price.

Zero-profit estimates show that even if truck transport is used (kr 220 per ton), it would be possible to pay more than kr 1.0 per kg for capelin. Variations in the quantity of production will not be of much significance, provided that the production is not reduced dramatically. When considering ensilage that is not heat-treated, one finds that even small variations in these factors are of significance to production profitability.

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A number of fish farm operating costs depend on the feed factor and therefore also on the energy content in the capelin. The operating costs are also affected by the feed losses. In these estimates, it is assumed that the basis for ensilage production is fresh or frozen capelin. This means that if the raw material quality leads to a change in one of the feed factors, the feed factor for the alternative uses also must be changed. When frozen capelin is used as a comparison, the feed factor, by the use of heat-treated ensilage for acid feed, varies to the same extent, and the relationship between the two feed types does not significantly change. Variations in the feed factor are therefore not particularly important to the cost of capelin used for ensilage and heat treated. Normal ensilage, however, requires a completely different mix of binding agent. The binding agent is thus a stabilizing factor which makes the feed factor vary only slightly. Accordingly, small variations in the capelin energy content could change the cost-wise relationship to wet feed made of frozen capelin. The lower the energy content in the capelin, the better the acid feed compares with the wet feed, but most of the energy then comes from the binding agent. An increase in feed waste will for all types of acid feed mean that these are preferable to wet feed. This effect is most significant for non-heat-treated ensilage.

The factor which most strongly influences the price that an ensilage facility can pay for raw materials is the price of frozen capelin. If this price is changed by, for instance, kr 0.20 per kg, the price of capelin for normal ensilage could be changed by kr 0.56 per kg and for heat-treated ensilage by kr 0.26 per kg. A small price increase in frozen capelin would thus mean significant profits for all types of ensilage operations with similar production volumes. However, a reduction in the price to kr 0.90 per kg of frozen capelin would mean that the capelin market price could not be paid.

Whether such a drop in the price of frozen capelin is likely, should be subject of a special study. Also , it may also be interesting to see the consequences, if several important factors happened at the same time to weigh in the same direction.

In the light of what has been stated, an operator who wishes to produce heat-treated ensilage should be able to invest quite a lot more in heat treatment equipment than the going price today. Nonetheless, a current-value investment analysis has been done which confirms the results above. The investment analysis is based on the assumption that the operation sells 2 000 tons of heat-treated ensilage during the first year, 5 000 tons in the second year and from then on 10 200 tons each year. Depreciation was set at 15% and the interest rate at 13.5%. Using the cost pattern that was used for the other calculations and assuming market price of capelin, it would be possible to invest several more millions of crowns in heat-treating equipment than such equipment actually costs today. An increase in the price of fresh capelin would mean a significant reduction in the maximum investment, as would a drop in the price of heat-treated ensilage below the maximum price. However, the margins are significant, and variations in individual factors would not prohibit a profitable investment. Even with a sale price of only 1 kr per kg, it should still be possible to invest over 2 million kr in heat-treatment equipment and still remain profitable. A shorter depreciation time is not particularly significant, unless the other factors at the same time show a particularly unfavourable trend.

Given the assumptions for this study, the conclusion can be briefly stated:

Market prices can be paid for capelin intended for ensilage without heat treatment.

Well over the market price can be paid for capelin intended for heat-treated ensilage.

An investment in heat-treatment equipment would be profitable even if the cost of such equipment becomes greater than it is today.

1. INTRODUCTION

1.1 WHAT IS ENSILAGE?

The principle behind ensilage consists in the fact that weak organic acids have an antimicrobic effect at low pH values. The reason for this is that, as the pH decreases, more and more of the acid is present in its undissociated form. In this form, the acid is capable of passing the cellular membranes of the bacteria, thus penetrating the bacteria. Here the pH is neutral. This causes the acid to dissociate and the pH to drop. The effect on the cells is toxic, and the bacteria subsequently die (Raa & Gildberg, 1982).

The antimicrobic effect of the acid is the greatest when the pH drops so far that 50% or more of the acid is undissociated, the so-called pK_a value. The acids used most frequently have a pK_a value of approximately 3.75 (formic acid) to 4.87 (propionic acid). Consequently, the pH value must not be lowered as much as when inorganic acids are being used, because these kinds of acids are completely dissociated at such low pH values.

Fish is equipped with a great buffering capacity. It takes relatively large quantities of acid to lower the pH. This means that acids with a high pK_a value are particularly well suited. Propionic acid is also effective against fungi , such as Aspergillus flavus which produces an aphlatoxin (Ibid.). Propionic acid is not good for salmon. This acid should not be used, therefore, for ensilage destined to be fish feed. Instead, formic acid should be used. In order to prevent the growth of fungus, 0.1% sorbic acid should be used (Raa, personal communication). In order to obtain a

stable ensilage, 2.2% formic acid as well as sorbic acid are recommended (Ibid.). In some ensilage facilities, levels as high as 3.0% of formic acid are even being used. In my own calculations, I shall be using the amount of 2.5% formic acid, as this is the customary amount (Høydal, personal communication).

The enzymes which are naturally present in the fish undergoing the process 2
of ensilation will be close to the optimum pH in the case of the customary ensilage referred to above [2.5% formic acid]. The result is that after a certain period of time, the fish will completely autolyze, or decompose. When this kind of ensilage is to be used as fish feed, large quantities of a binding agent must be added. The finished product will consist of as much as 50% binding agent and 50% ensilage (Raa, personal communication). By treating the ensilage with heat, the enzymes may be inactivated which will bring about the cessation of the autolysis. In that case, 15% binding agent will be sufficient in the finished product (Ibid.). The ensiling process will proceed in the usual manner, using the amounts of acid referred to above. The ensilage will then be transferred directly to a heat treatment facility where it is heated to 95°C and subsequently to a storage tank (Myrland, 1983). As an alternative, one may add 1.5% molasses, 0.1% sorbic acid and 0.7% formic acid as a prepreservation measure in an intermediate tank (Raa, pers. com.). The fish mass would then be heated to 80°C in a heat exchanger thus stopping the autolysis. The ensilage is now transferred to a storage tank where a start culture of lactic acid bacteria is added. Lactic bacteria feed only on molasses. The fish will therefore not be down graded, nor will it rot. On the contrary, the lactic bacteria will produce lactic acid and antibiotica that strengthen the antimicrobic effect

(Raa & Gildberg, 1982). Already in the introductory phase of the lactic acid fermentation, the molasses will prevent the bacteria from producing enzymes which may downgrade the amino acids (Ibid.). The primary advantage of this type of ensilage is that the quantity of acid is low. All the types of ensilage referred to kill pathogenic bacteria, including Vibrio (Raa, pers. com.).

1.2 DEFINITION OF PROBLEM

Frozen capelin for fish feed today costs approximately N.Kr. 1.50 per kg from the supplier. The fish has to be mixed with 10% binding agent which costs Nkr. 4.75 per kg, before it can be used as feed. There are the following alternatives:

-Ensilage made from fresh capelin. The ensilage will then have to be mixed with 50% binding agent before it may be used as feed.

-Ensilage made from fresh capelin which is then treated with heat. This ensilage has to be mixed with 15% binding agent before it may be used as feed.

-Heat treatment and lactic acid ensilage of capelin raw material which has been prepreserved with a relatively small amount of acid and mixed with molasses prior to the heat treatment. 15% binding agent must be added before the product may be used as feed.

The problems are:

-What is the maximum payment for capelin raw material to be used for ensilage, and possibly for heat treatment, when the fish farmer pays a certain price for frozen capelin and when a binding agent is required in the amounts referred to above?

-What is the maximum amount you may expect to have to invest in equipment for heat treatment of the ensilage in order to stop the autolysis, in order that a binding agent of only 15% is required?

-What is the maximum amount you may expect to pay for lactic bacteria if you use lactic acid ensilage,with 1.5% molasses and 0.7% formic acid added, instead of acidic ensilage? This amount will be measured against acidic ensilage.

In order to be able to answer these questions, it is necessary to estimate the costs incurred by the farming facilities when manufacturing feed from the various types of ensilage as well as from frozen capelin. Wet feed from frozen capelin will constitute the basis of comparison in these calculations. The types of feed will be compared on the basis of energy, i.e., the cost per kg of fish produced will be considered. In addition, the costs of production and distribution of the various types of ensilage must, naturally, be taken into account. The market price of capelin will also be used in some of the calculations contrary to the maximum amounts otherwise used in my calculations. Individual factors have a great impact on the results of the calculations. It is therefore necessary to take into account also the following question:

-How sensitive are the maximum prices paid for capelin raw material and the maximum amounts to be invested in heat treatment equipment, to variations in fundamental factors.

2. FULL COST METHOD

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According to the full cost method, all costs connected with the production of a product are included in the cost price of the product (Naug & Flakke, 1980). The full cost is calculated on the one hand as the sum of direct and indirect costs, and on the other hand as the sum of variable and fixed expenses (Ibid). By adding the desired profit to the full cost, the sales price of the product is arrived at. The direct costs are attributed to the product causing the costs, whereas the indirect costs are distributed on the various products being produced (Ibid.). If we are dealing with only one product, such a distribution is not required. In the variable costs are included the direct use of material, direct salaries, indirect materials, social costs in connection with direct wages, repairs, maintenance, direct sales costs as well as the cost of electricity. In the fixed expenses are included overhead, write-offs, and interest payments on invested capital. If there are other costs, either variable or fixed expenses, these must be calculated as well.

The calculations will take as their point of departure the full cost figure that constitutes the indifference between the use of wet feed from frozen capelin and acidic feed from the various types of ensilage at the individual

farming facilities. This full cost figure is being used as a basis for my calculations in order to calculate, first of all, what will be the maximum amount to be paid for ensilage by the fish farm in question. The next step is to fix this maximum price as equal to the maximum sales price for the ensilage facility. A new full cost calculation is then made in order to arrive at the maximum price that the ensilage facility is able to pay for capelin. The calculations pertaining to ensilage are precalculations, i.e. a way of showing what a product may be expected to cost (Ibid.) or, in this case, what will be the maximum price of one of the factors. The full cost calculations will also provide the answer to the question of the maximum amount to be expected to be paid for lactic bacteria.

3. THE ENSILAGE FACILITY 5

3.1. PRODUCTION VOLUME

It is here assumed that an ensilage facility will be supplying ensilage or heat-treated ensilage for an annual production of 4000 tons of fish. This corresponds to the total quantity for 1982 for the entire northern part of Norway, including parts of South Trøndelag, or approximately 45% of the total quantity down to and including Møre and Romsdal (8787 tons in 1982 (Jamtøy, pers. com.)). Ensilage is a relatively new feed for fish, and the heat treatment of ensilage brings about completely new properties which are little known among the fish farmers. It is therefore difficult to predict the demand with any accuracy before potential customers have been properly informed and consulted. In this connection, it should be pointed out that

the business is growing rapidly thanks to the present expansion of the consession limit to 8000 m³. The main portion of Norway's fish farming is situated still farther south. In addition, ensilage is also being used as feed for furred animals and domestic animals. When calculating the amount of ensilage required to produce 4,000 tons of fish, the feed factor for the type of feed concerned must be taken into account, i.e., the amount of feed required tc produce 1 kg of fish. The feed factor, in its turn, is dependent on the amount of feed loss and on the content of energy in the feed.

When calculating on the basis of the feed factor for feed with a known content of energy, it is realistic to expect a feed loss of approximately 40% in the case of acidic feed and approximately 48% in the case of wet feed from capelin (Karlsen, pers. com.). These values will be used as approximations in my calculations.

The content of energy in capelin varies according to the time of year. It is calculated on the basis of percentage of fat and percentage of protein. The fat content varies considerably, and during the summer months it may rise to well above 20% (The Fisheries Directorate, 1978-1982). 6
In the course of the winter and spring, the fat content gradually decreases, and it may go as low as 1% late in the spring (Ibid.). The content of protein varies only marginally. When calculated as MJ convertible energy (MJ OE), fat yields 33.5 MJ OE per kg and protein yields 16.3 MJ OE per kg (Skretting, 1983-84; Austreng, 1981). The ensilage may be produced by using completely fresh capelin or by using capelin preserved with V65 (Raa, pers. com.). The average content of energy in such an ensilage ought therefore to be

calculated on the basis of the average of the content of energy of capelin caught during the winter, of capelin caught during the summer in the Barents Sea and at Jan Mayen -- measured while taking the quantity of the catch into account. Data from the Fisheries Directorate's statistics on factory raw material for 1978-82 indicate an average content of fat of 14.43%. See Appendix 1. Assuming that the fat-free dry material used in the statistics contain 1.9% ashes (Anon, 1976), and deducting this figure in order to arrive at the percentage of protein, the result is 12.34% protein. Capelin thus contains an average of 4.8 Mj OE energy in the form of fat and 2.0 MJ OE in the form of protein, i.e. the average content of energy is 6.8 MJ OE per kg capelin. This figure is used as a basis for my calculations.

It takes 13.5 MJ OE to produce one kg of fish at a fish farm (Austreng, 1981). I will be using the following terminology in my calculations:

F = feed factor = the amount of feed required to produce one kg of fish.
y = content of energy in the feed measured as MJ OE.
x = content of energy in capelin measured as MJ OE.
V = frozen capelin or wet feed with 10% binding agent.
E = usually non-heat-treated ensilage or acidic feed from such ensilage.
S = feed loss of acidic feed in percentages, expressed in decimals.

A list of these and other symbols may be found in Appendix 2. I am using the Tess acidic feed meal as a binding agent. It has a content of energy of 12.6 MJ OE per kg (Skretting, 1983-84). The loss of feed is expressed as follows:

$S = (F-(13.5/y))/F$ (Austreng, 1981).

This means that F may be desribed roughly as follows:

$F = 13.5/((1-S)y)$.

By using the average content of energy in capelin and the known quantity mixed into the capelin, the feed factor for ensilage and wet feed may be calculated. The ensilage consists of the following components:

E: Capelin 97.4%. Formic acid 2.5%. Sorbic acid 0.1%. The ensilage has a content of energy of 0.974 multiplied by the content of energy in capelin.

When the content of energy in the binding agent is 12.8 MJ OE and the content of energy in capelin is 6.8 MJ OE, this may be expressed in relation to F as follows: $F_V=3.52$. $F_E=2.34$.

It is sufficient to use one decimal when determining the production volume for the ensilage facility. Two decimals should be used for the other calculations even though this is not followed in practice at the fish farms. Consequently, I will be using an average feed factor of F=2.3 for ordinary ensilage when I determine the corresponding production quantities. In addition, it is necessary to take into account the mixed-in binding agent: 50% required for the finished feed product. The production volume corresponding to a given production of fish at the fish farming facilities is therefore:

The ensilage production in tons = Quantity of fish produced in tons x feed factor x amount of ensilage in the feed.

The equation is now:

The number of tons of ensilage = (4000 x 2.3 x 0.5)tons = 4600 tons.

3.2. ENSILAGE FACILITY INVESTMENTS

It is assumed that the processing equipment may be placed in already existing buildings.

3.2.1. Unloading Equipment and Intermediate Storage

It is a requirement to be able to take in an entire catch of fish caught in a purse seine in order to be on a competitive footing with the herring oil/fish meal industries with regard to raw material. This means that the unloading equipment has to be efficient and that the capacity for intermediate storage of an average catch of fish caught in a purse seine has to be approximately 6000 hectoliters. Cf. Figure 1.

A.S Løwener, Mohn, is a supplier of Netzsch unloading pumps which have a virtual monopoly in today's market. A Netzsch N150 mono-pump has a capacity adjustable up to 210 m³ an hour at pressures up to three bars. The pump is made of steel and has a Pleiger radial piston engine.
A hydraulic aggregate is required consisting of a tank and an adjustable pump with a remote control motor. The power requirement is 75 kW per hour (Jessen, pers. com.). A hose is required, 15 meters long, to lead the mass of capelin onto the measuring apparatus. A place to hang the hose is also needed. A suction pipe with additional equipment facilitates the unloading. The total price is approximately N.Kr. 250,000 when delivered

in Tromsø (Ibid.). The pump is hanging from a crane or boom and is lowered hydraulically. See Figure 2.

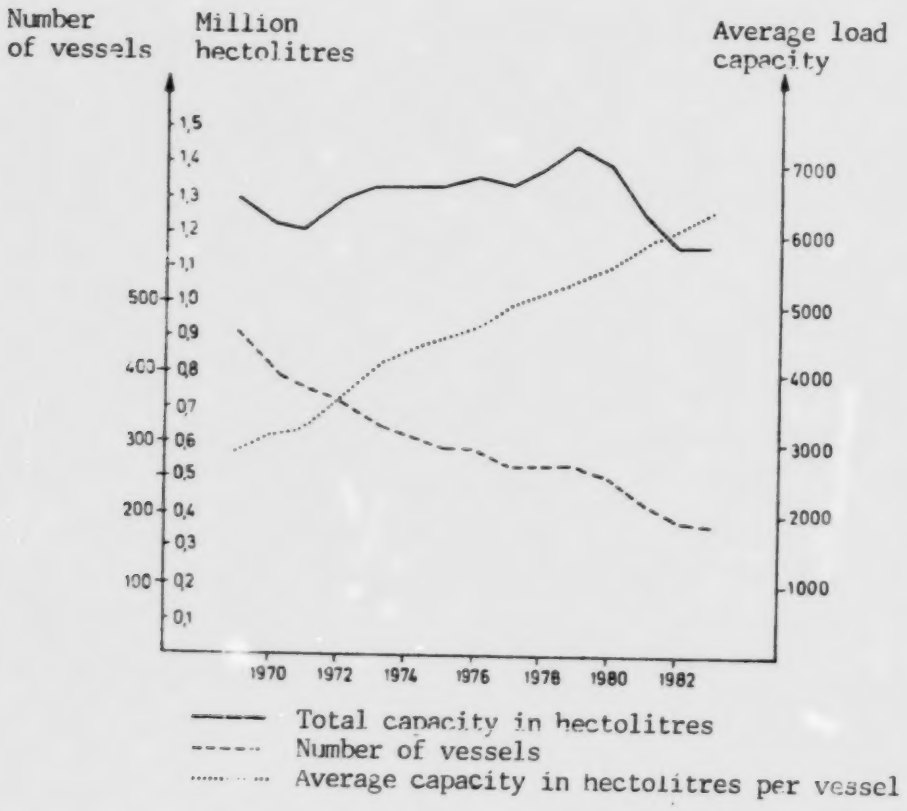

Fig. 1. The development of the loading capacity of the seine net fleet from 1969 to 1983 in total amounts and per vessel (Department of Fisheries, 1982-83).

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The next step is to determine the volume of the capelin. Brødr. Hetland A.S. in Bryne supplies a HMK 100-2 rotating measuring aggregate with a capacity of 2800 hL capelin an hour (Gilje, pers. com.), i.e. 280 m³ an hour. The fish enters at the top, and four rotating devices measure the amount of capelin in hectolitres by means of an electronic counting device.

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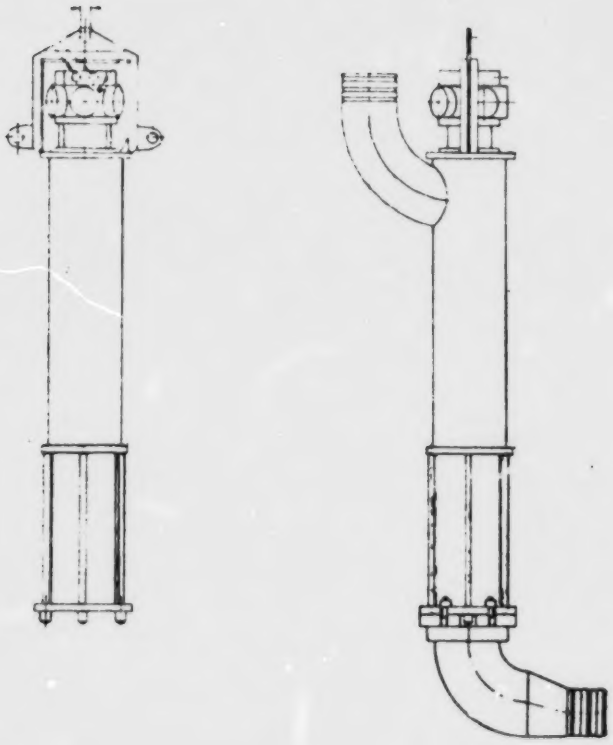

Fig. 2. Netzsch N150 mono-pump for the unloading of capelin. To the right, a suction pipe is shown mounted to the pump.

The aggregate is run by a 3 kW powered wormgear motor. The aggregate costs N.Kr. 214,000 when delivered in Bryne, and the installation is simple. The freight between Bryne and Tromsø amounts to approximately N.Kr. 10,000 and the installation costs roughly N.Kr. 4,000 (Ibid.). The total cost will be approximately N.Kr. 228,000. See Figure 3.

Underneath the measuring aggregate a new pump is installed for the transportation of the capelin into the intermediate tanks. A Netzsch NES150A model

Fig. 3. Brødr. Hetland HMK 100-2 measuring aggregate for capelin.

well suited for this purpose. The same data apply as for the unloading pump N150 (Jessen, pers. com.). A new aggregate is required. It is the same price as the N150 (Ibid.). The additional equipment is not required, however. I therefore use the figure of N.Kr. 235,000 as an approximation. Supplier: A.S Løwener, Mohn. See Figure 4.

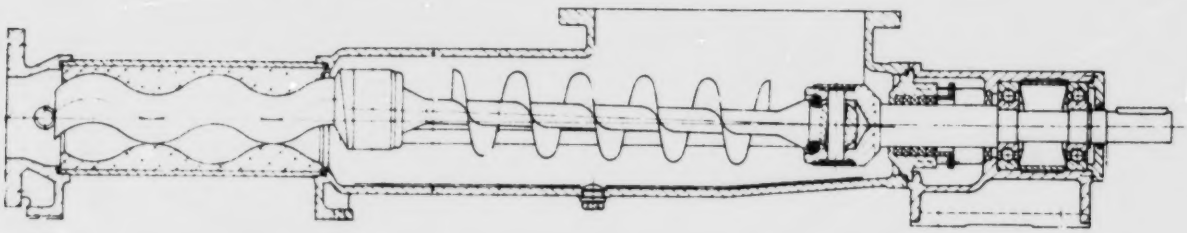

Fig. 4. Netzsch NES150A mono-pump for the transportation of capelin.

The capelin may be stored in one or several intermediate tanks totalling 600 m³ or more. They need not be insulated, and may have a very simple design (Raa, pers. com.). Prices vary considerably. I therefore prefer to use a high estimate: N.Kr. 1.56 per litre storage capacity according to an estimate by Landteknikk A/L (Myrland, 1983). Consequently, I will be using the estimated figure of N.Kr. 936,000 as the amount required to purchase intermediate storage tanks with a capacity of 600 m³. 11

3.2.2. Processing Equipment

In the following, the ensiling process is indicated as an E.

Hamjern A/S in Hamar is a supplier of complete ensilage installations as shown in Figure 5. The capelin is transferred from the intermediate tanks to the in-take. The desired amount of acid is added automatically by means of an acid injection regulator pump. The ensilage is moved on via a pH sensor to a storage tank. This installation has been modified from earlier models. The capacity is now approximately 10 tons an hour when using the equipment to process capelin (Bjørge, pers. com.). The energy consumption amounts to 30 kw for the grinder, 4 kw for the pump, and 1 kw for the feeding screw/ acid pump, i.e. a total of 35 kw (Ibid.). The installation is automated. The installation as shown in Figure 5, excluding the storage tank, costs approximately N.Kr. 185,000 in addition to roughly N.Kr. 2,000 for the freight from Hamar to Tromsø and roughly N.Kr. 25,000 to have it installed. The total cost is thus approximately N.Kr. 212,000 (Ibid.).

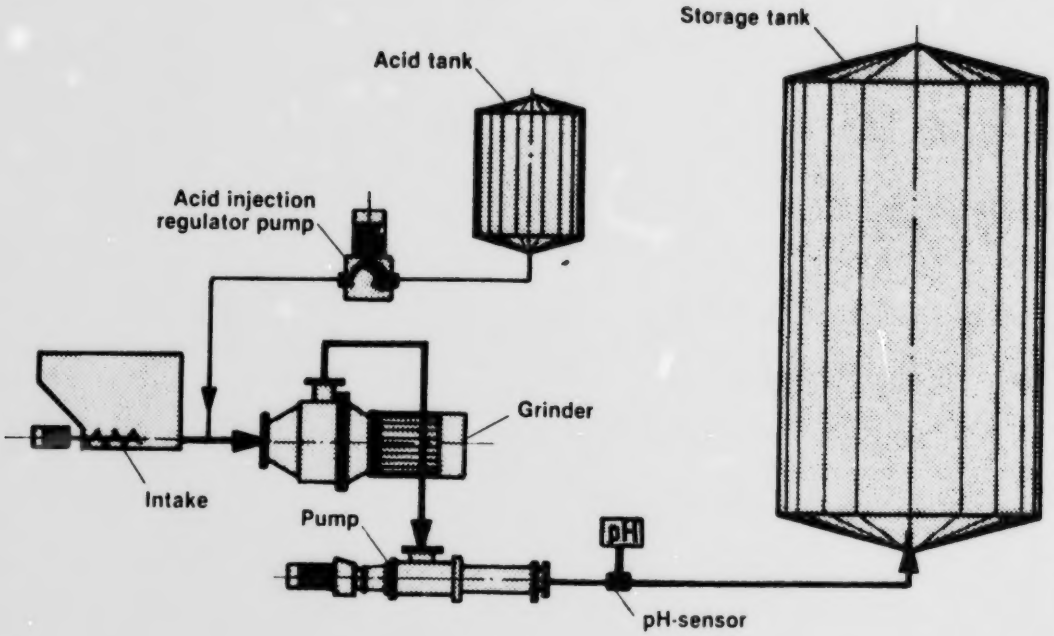

Fig. 5. Hamjern ensilage installation including storage tank.

3.2.3. Storage Tanks

The raw material must be processed as quickly as possible. I assume that the finished product will be distributed continuously so that the storage capacity will not have to be as great as the storage capacity of the intermediate tanks. It is also assumed that the uninsulated intermediate storage tanks may, to a certain extent, be used as storage tanks should the need arise. Finally, it is assumed that a storage capacity of 400 m^3 is sufficient to receive 600 tons of capelin each time while production is in process. These figures are, therefore, being used in my calculations.

The cost of intermediate as well as non-intermediate storage tanks varies considerably depending on design and location of the facilities. Non-insulated plastic tanks may be used for intermediate storage. Such tanks cost approx- 12
imately N.Kr. 1.50 per litre in addition to the cost of shipping (Lyngen Plastfabrikk [factory producing plastic], personal communication). This means that the cost will be about the same as for the tanks manufactured by Landteknikk. Concrete tanks are considerably cheaper in locations where there is good access to cement, such as in Tromsø. In other locations, concrete tanks may, or may not, be cheaper (Helgeland Betongvarefabrikk [cement factory], pers. com.). In the most favourable of circumstances, the price per litre may be as low as between N.Kr. 0.80 and 1.00. In such a case, the cost of the tanks may be cut in half. If the tanks are to be insulated, this will cost extra. Since the aim of my calculations is to estimate the maximum price of capelin as well as the maximum cost of heat treatment equipment, a high estimate of the cost of tanks will be safer.

3.2.4 Total Investments 13

A 10% investment tax on the total investment, including shipping and installation costs, is used in my calculations. The total amount is then N.Kr. 3.173,500. See Tables 1 and I.

It is assumed that outdoor, insulated storage tanks have been chosen and that no building will be built around them. The price will be roughly the same (Sketch, -). I have chosen the figure of 15% in my calculations for the annual write-offs, and the average annual interests have been set at 13.5% of half of the amount invested. This results in annual write-offs in the

amount of N.Kr. 476,025 or N.Kr. 103.5 per ton of ensilage when the production is 4600 tons annually. The interests will amount to N.Kr. 214,211 or N.Kr. 46.6 per ton of ensilage. See Table II.

Table 1. Total investments required for an ensilage installation.

ITEMS TO BE PURCHASED	TOTAL INVESTMENT E
Netzsch N150 mono pump	250,000
HMK 100-2 rotating measuring device	228,000
Netzsch 150A pump	235,000
Intermediate storage tanks,600 m^3	936,000
Hamjern processing equipment	212,000
Storage tank of 400 m^3	1,024,000
Subtotal	2,885,000
10% investment tax	288,500
Total cost of investment	N.Kr 3,173,500

3.3 OPERATION OF THE ENSILAGE FACILITY

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3.3.1 Maintenance and Repairs

Maintenance and repair are estimated to cost 4% annually of the total amount invested. The result is N.Kr. 126,940 or N.Kr. 27.6 per ton of ensilage. See Table III.

3.3.2. Wages

An arrangement of three shifts is assumed, and it is based on a machinist's wage of N.Kr. 63.10 an hour in effect in the fourth quarter of 1982. There is an additional payment of 16% for the evening shift and 25% for the night shift (Følstad, pers. com.). This means that the average wage is N.Kr. 72.- an hour. Even though the facilities are automated, the presence of a man is nevertheless required while the installation is in operation. It is assumed that there is an amount of 97.4% capelin in the ensilage E. The net weight varies from one kind of fish to the other, but one hectolitre of capelin weighs 97 kg.

E: Unloading facilities:	$\left(\frac{4600 \times 0.974 \times 1/0.97}{210} 72\right) =$	1,584
Ensilage:	$\left(\frac{4600 \times 1/0.97}{10} 72\right) =$	34,144
	N.Kr.	35,728

The cost per ton of ensilage is thus: (35,728/4600)=N.Kr. 7.8 per ton

3.3.3. The Cost of Acid

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Formic acid costs N.Kr. 154.10 in addition to a charge of N.Kr. 18 (redeemable) for a 25 litre container (Felleskjøpet Tromsø, pers. com.). That is N.Kr. 5.44 per kg. When delivered in a pallet tank, it is somewhat cheaper: N.Kr. 3,145 per ton (Norsk Hydro, pers. com.). Shipping costs are in addition to those figures. Given that we are dealing with the distance between Porsgrunn and Tromsø, the freight will amount to N.Kr. 2,549 per ton in addition to the N.Kr. 200 (redeemable) for the tank (Tromsø Skipsekspedisjon, pers. com.). That is N.Kr. 5.89 per kg, i.e. somewhat more expensive unless some other

means of transportation may be arranged. It should be possible to have acid delivered in a container for as low as N.Kr. 4.00 per kg (Stormo, pers. com.). In my calculations, I am using the figure of N.Kr. 5.44 per kg which corresponds to the costs at the ensilage facilities at Myre (Høydal, pers. com.).

Sorbic acid costs N.Kr. 15 per kg (Raa, pers. com.). The costs of acid are therefore:

$$\text{E: Total: } \left(\frac{4{,}600{,}000 \times 2.5}{100}\ 5.44 + \frac{4{,}600{,}000 \times 0.1}{100}\ 15\right) = \underline{\text{N.Kr. } 694{,}600}$$

$$\text{Per ton ensilage: } (694{,}600/4{,}600) = \underline{\text{N.kr. } 151.00}$$

3.3.4 Distribution

A tanker truck is well suited for the transportation of relatively small quantities of ensilage over short distances. Within a radius of approximately 20 miles, the cost of distribution amounts to N.Kr. 220 per ton, regardless of the distance (Høydal, pers. com.). If we are dealing with the transportation of relatively large quantities over a long distance, transportation by boat would appear to be the more opportune means. In the case of purse seines of 5,000 - 6,000 hectolitres of capelin, the transportation costs of capelin will be about N.Kr. 11 per hL from Honningsvåg to Ålesund, including the return trip without a load (Ingebrigtsen, pers. com.). Frighters will surely be able to do this more cheaply. In my calculations, I assume that the cost of transportation will be within the range referred to above.

I am using the figure of N.Kr. 100 per ton as an average as a large portion of the ensilage will have to be transported south to the western part of the country. This estimate is surely high, but it is assumed that other variable sales costs might also be included in this amount. 16

E: Total costs: (4,600 x 100)= N.Kr. 460,000

3.3.5 Energy Consumption

It is assumed that the cost of electricity will be N.Kr. 0.25 per kw hour It is further assumed that the measuring apparatus is in operation all the while the pumps are operating.

Consumption of energy:

The unloading facilities: (75 + 3 + 75) = 153 kw

The ensilage installation: 35 kw

The result is the following number of hours of operation per annum:

The unloading facility E: $\left(\frac{4,600 \times 0.974 \times 1/0.97}{210}\right)$ = 22 hours

The ensilage installation E: (4,600/10) = 460 hours

If we multiply the energy consumption figures by the number of hours of operation and the price of N.Kr. 0.25 per kw hour, the cost of electricity will be N.Kr. 842 in the case of the unloading facility and N.Kr. 4,025 in the case of the processing equipment, a total of N.Kr. 4,867 or N.Kr. 1.1 per ton of finished ensilage.

3.3.6 The Market Price of Capelin

A market price of N.Kr. 45 per hectolitre of capelin is assumed. That is approximately N.Kr. 460 per ton of capelin. The price will vary according to the content of fat and dry matter. However, the figure of N.Kr. 460 per ton should correspond roughly to the market price for capalin containing an average amount of energy.

The costs are:

E: Total:	(4,600 x 0.974 x 460) =	2,060,984 N.Kr.
Per ton of ensilage:	(460 x 0.974) =	448.0 N.Kr.

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3.4 CALCULATION OF THE FULL COST FOR THE ENSILAGE FACILITY

We now have sufficient data to calculate the full cost of the production of ensilage from capelin raw material. The cost of lactic bacteria is excluded. The unit price is indicated per ton of finished ensilage. The calculations are shown in Tables 2 and V.

The calculations indicate what will likely be the full cost of producing ensilage from capelin bought at a market price of N.Kr. 0.46 per kg.

In order to arrive at the maximum price to be paid for capelin for ensilage, we must use, as our point of departure, that sales price at which the fish farmer is indifferent in his choice between frozen capelin for wet feed and ensilage for acidic feed, and set that sales price as equalling the full cost. 18
In order to be able to do that, an overview of the costs involved at the fish farming facilities is required.

Table 2. Calculation of the cost of producing ensilage (E) when the price of capelin equals the market price. 17 cont.

COSTS	TOTAL COSTS E	COST PER UNIT E
VARIABLE COSTS		
Capelin	2,060,984	448.0
Acid	694,600	151.0
Wages	35,728	7.8
Electricity	4,867	1.1
Maintenance/repairs	126,940	27.6
Distribution	460,000	100.0
TOTAL OF VARIABLE COSTS	3,383,119	735.5
FIXED EXPENSES:		
Write-offs	476,025	103.5
Interest payments	214,211	46.6
TOTAL OF FIXED EXPENSES	690,236	150.1
FULL COST TOTAL	4,073,355	885.6

4. FISH FARMING FACILITIES 18 cont.

A feed based on capelin, be it frozen or as ensilage, with an additional binding agent of 10% or more, covers all the nutrition requirements of a fish. Other types of feed are therefore not required (Molvik, pers. com.). Nevertheless, it is customary to provide dry feed for the first while after the fish have been put into the holding ponds at the fish farming facilities.

My point of reference is a 8000 m³ facility where there is an annual production of 160 tons of fish, and where either wet feed from frozen capelin or acidic feed from ensilage is being used as feed. This production corresponds to 32,000 fish each weighing approximately 4.5 kg. If we have 35,000 fish each weighing approximately 1 kg, the total amount of fish is 195 tons. This gives us a density of about 24 kg per m³ for the entire fish farm. This is not uncommon in practice.

4.1 BASIC ASSUMPTIONS

Ensilage is to be compared with frozen capelin. Wet feed made from frozen capelin requires 10% binding agent (Raa, pers. com.). (Frozen capelin and wet feed made from frozen capelin will be indicated by a "V" in the following.) The binding agent is added manually to V, but I assume that a silo for the binding meal is required in the case of E. The storage capacity should be about the same. In my calculations, it is further assumed that a freezing capacity of 300 m³ is appropriate in relation to a storage tank of 100 m³ when taking into account the feed factor, empty space in the freezer (the product being moved in and out) and the binding agent to be mixed into the product.
It is not likely that tanks for acidic feed of such proportions can be placed indoors in already existing buildings. It is therefore necessary to either build a structure around the tanks or to insulate the tanks. In either case, the cost will amount to approximately N.Kr. 1.00 per litre of storage capacity (Sketch,-). I will be using this figure in my calculations to indicate the cost of insulating the tanks.

In my calculations, the costs cover the production of feed up to and including the pelletization process. The costs after this process

vary considerably according to the facilities, the design, and the degree of automation. Consequenstly, these costs have not been included in my calculations. (Due to the feed factor which is higher in the case of wet feed and lower in the case of E, any inclusion of these figures will be in the disfavour of wet feed.)

Further, it is assumed that existing buildings will be used. Other kinds of feed are completely excluded. The need for freezing space (for shrimp shells, for example) is assumed to be absorbed in the cost of the remaining operation. The equipment which is relevant for the production of feed is considered to have more than a sufficient capacity to cover the demand. Likewise, the trucking required for the transportation of frozen capelin is assumed to be absorbed by any slack in the remaining operation, thus rendering any extra costs negligible. The costs of shipping and installation have not been included for each of the items purchased, as such costs depend strongly on the place of origin of the product in question. As an approximation, an additional amount of 10% of the investments may be assumed to cover the cost of shipping and installation.

4.2 INVESTMENTS

The total costs of investing in the fish farm is shown in Table 3. See also Table VII.

Table 3. Investment costs in connection with fish farms involved in the production of feed from frozen capelin (V) or ensilage (E) when the capacity is 8,000 m³. 20

ITEMS TO BE PURCHASED	8,000 m³ V	8,000 m³ E	
Freezing capacity 150/300m³	315,000	-	(Juliussen, pers.com.)
Crusher	22,500	-	(Eidnes, pers. com.)
Grinder Wolfking F-160	31,000	-	(Ibid.)
Storage tank, N.Kr. 1.56 per litre	-	156,000	(Myrland, pers. com.)
Insulation, N.Kr. 1.00 per litre	-	100,000	(Sketch, -)
Pump	-	15,000	(Ibid.)
Pipes, cranes	-	20,000	(Ibid.)
Silo for binding agent, 25 m³ (Indoor)	-	11,200	(Kjelsberg, pers. com.)
Screw/motor	-	3,000	(Ibid.)
Stand for silo	-	3,000	(Ibid.)
Pelletization equipment 1,500/100 including safety plate	60,500	60,500	(Eidnes, pers. com.)
TOTAL INVESTMENT COSTS	429,000	368,700	
10% freight and installation	42,900	36,870	
TOTAL INVESTMENT COSTS AFTER INSTALLATION	471.900	405,570	
10% investment tax	47,190	40,557	
TOTAL INVESTMENT COSTS	519,090	446,127	

I have decided to use the figure of 15% for the annual write-off of equipment, the figure of 8% for the annual write-off on freezer rooms, and the sum of 13.5% per annum of half of the investment costs to cover interest payments.

The amount to be written off for the freezer room will be the total investment costs plus freight/installation plus investment tax. Provided that freight/ installation amounts to 10% and that the investment tax is 10%, the amount on which the write-off should be based will be N.Kr. 381,150. See also Table VIII. When the remainder of the fish farm is written off by 15% per annum, the annual write-offs will be N.Kr. 30,492 for freezer capacity and N.Kr. 20,691 for equipment, totalling N.Kr. 51,183 for V. That is N.Kr. 0.320 per kg of salmon. The total write-offs forE will be N.Kr. 66,919, or N.Kr. 0.418 per kg of salmon. See Table IX.

The annual interest payments will amount to N.Kr. 35,039 in the case of V, or N.Kr. 0.219 per kg of salmon. In the case of E, the interest payments will amount to N.Kr. 30,114, or N.Kr. 0.188 per kg of salmon. See Table X.

4.3 OPERATIONS

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4.3.1 Maintenance and Repairs

Provided that the costs of maintenance and repairs are 4% per annum of the total investment costs, these costs will amount to N.Kr. 20,764 in the case of V and N.Kr. 17,845 in the case of E, or N.Kr. 0.130 and N.Kr. 0.112 per kg of salmon for V and E respectively. See Table XI.

4.3.2 Consumption of Feed

It is assumed that there is a loss of feed of 48% in the case of wet feed

and a loss of feed of 40% in the case of acidic feed, and that the average yearly content of energy is 6.8 MJ OE (transformable energy) per kg in capelin and 12.6 MJ OE per kg in the binding agent (Skretting, 1983-84). The feed factors are: F_V=3.52; F_E=2.34. When multiplying the annual production by the feed factor, the result is an annual consumption of feed of 563.2 tons of wet feed and 374.4 tons of ensilage. See Table XII.

4.3.3 Binding Agent

The binding agent costs N.Kr. 4.75 per kg (Skretting, 1983-84). This cost is arrived at by multiplying the following factors: consumption of feed, percentage of binding agent, and price. The result is a cost of N.Kr. 267,520 in the case of V and N.Kr. 889,200 in the case of E, or N.Kr. 1.672 and N.Kr. 5.558 per kg of salmon for V and E respectively. See Table XIII.

4.3.4 Wages

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It is assumed that the workers have other duties. I am therefore only calculating the approximate number of hours required for the actual production of feed. It is assumed that there is a daily production of feed. It is also assumed that one hour a day is used for trucking, cleaning of equipment, floor, etc. in the case of wet feed. Ensilage is produced in a closed system which makes the cleaning process easier. One half hour of cleaning, etc. a day is assumed. In addition, we have the production itself of the feed. An hourly wage of N.Kr. 55 is assumed. This amount includes an employer's tax and contributions for social benefits. The capacity of the pelletization machine

is 1.5 tons an hour (Eidnes, pers. com.). The wages therefore amount to N.Kr. 40,451 in the case of V and N.Kr. 23,628 in the case of E, or N.Kr. 0.253 and N.kr. 0.148 per kg for V and E respectively. The calculation is shown in Table XIV.

4.3.5 Consumption of Electricity

In my calculations it is assumed that a freezer room of 300 m³ requires 6 kw and that it is in use all year round (Juliussen, pers. com.). In addition, there are the following capacities and consumption of electricity:

Table 4. Consumption of electricity and capacity of equipment until the production of pellets has been completed.

ITEMS TO BE PURCHASED	CONSUMPTION OF ELECTRICITY	CAPACITY PER HOUR
Crusher	15 kw	5.5 tons
Grinder	7.5 kw	2.5 tons
Pellet machine	26 kw	1.5 tons
Motor/screw	1.5 kw	3 tons (est.)
Pump	4 kw (est.)	10 tons (est.)

The number of hours of operation depend on whether only capelin/ensilage, or both capelin/ensilage and the binding agent have to be put through the equipment in question. The quantity of feed to be produced depends on the feed factor. The cost of electricity is the product of the price of electricity, the quantity of fish produced, the feed factor and the consumption

of electricity, while taking the capacity and number of hours of operation into account. In the case of V, the total cost of the freezer room will be N.Kr. 12,960 and N.Kr. 3.237 for the equipment, i.e. a total of N.Kr. 16,197 or N.Kr. 0.101 per kg of salmon. In the case of E, the corresponding figures will be N.Kr. 1,688 and N.Kr. 0.011 respectively. See Table XV.

4.3.6 Cost of Frozen Capelin

In the spring of 1983, the price of frozen capelin was N.Kr. 1.40 per kg prior to February 22, and N.Kr. 1.35 after that date (Ingebrigtsen, pers. com.). In the case of sales of more than 100 tons, the price was N.Kr. 0.05 lower (Ibid.). Usually, the cost to the fish farmer is between N.Kr. 1.50 and N.Kr. 1.80 per kg (Sørensen, 1983). In my calculations, I will be using the price of N.Kr. 1.50 as an estimated average price. This results in a cost of N.kr. 4.752 per kg of salmon, i.e. a total of N.Kr. 760,320.

4.3.7 3,000 m^3 Fish Farms

I will also deal with fish farms of a capacity of 3,000 m^3. I assume that there will be an annual production of capelin-based feed equal to three eights of a farming facility with a capacity of 8,000 m^3, i.e. 60 tons of feed.

The calculation of the costs with reference to a fish farm with a capacity of 3,000 m^3 is carried out in the same way as those for a fish farm with

a capacity of 8,000 m³. It is assumed that the capacities of the equipment for the production of feed are the same, but that it is sufficient to have a 150 m³ freezer room and a storage tank of 50 m³ and that these volumes are proportionate in relation to each other when taking into account the mixing in of the binding agent, the feed factor, and unusable space in the freezer room. Otherwise there are the same assumptions as were the case when discussing farming facilities with a capacity of 8,000 m³. The data pertaining to a farming facility of 3,000 m³ are shown in Tables VI to XVI, and in the Tables 3 and 4. The costs in connection with either size of facility are shown in the following full cost calculation (Table 5).

4.4 FULL COST CALCULATION

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We now possess sufficient data to set up a full cost calculation for the production of fish feed, be it from capelin raw material, ensiled or frozen. It is assumed that the fish farmer will be indifferent in his choice of feed if the total costs per kg of salmon are the same for the various types of feed. By using the fixed price of N.Kr. 1.50 per kg of frozen capelin, the total cost of producing wet feed from frozen capelin may be arrived at. By having the total cost (= the full cost per kg of salmon) of acidic feed made from ensilage equal the total cost of wet feed, we will arrive at that price of ensilage at which the fish farmer is indifferent in his choice between using frozen capelin for wet feed or ensilage for acidic feed. This cost of ensilage (E) has been incorporated in the full cost calculation for the fish farm and is shown in Table 5. See also Table XVII.

4.4 FULL COST CALCULATION

Table 5. Full cost calculation for the production of wet feed and acidic feed in fish farming facilities where the price of E has been set in such a way that the full cost of V equals the full cost of E (per kg of salmon).

COSTS	TOTAL COSTS				PER KG OF SALMON			
	3,000m³		8,000m³		3,000m³		8,000m³	
	V	E	V	E	V	E	V	E
VARIABLE COSTS								
Frozen capelin	285,120	-	760,320	-	4.752	-	4.752	-
Ensilage	-	76,312	-	162,080	-	1.270	-	1.012
Binding agent	100,320	333,450	267,520	889,200	1.672	5.558	1.672	5.558
Maintenance and repairs	14,956	11,650	20,764	17,845	0.249	0.194	0.130	0.112
Wages	27,544	15,048	40,451	23,628	0.459	0.251	0.253	0.148
Electricity for equipment	1,214	633	3,237	1,688	0.020	0.011	0.020	0.011
SUM OF VARIABLE COSTS	429,154	437,093	1092,292	1094,441	7.152	7.284	6.827	6.841
FIXED EXPENSES								
Write-offs	39,567	43,687	51,183	66,919	0.659	0.728	0.320	0.418
Interest payments	25,238	19,659	35,039	30,114	0.421	0.328	0.219	0.188
Electricity for freezer room	6,480	-	12,960	-	0.108	-	0.081	-
SUM OF FIXED EXPENSES	71,285	63,346	99,182	97,033	1.188	1.056	0.620	0.606
FULL COST	500,439	500,439	1191,474	1191,474	8.340	8.340	7.447	7.447

The figure for capelin/ensilage in the table above indicates the price of a quantity of corresponding F multiplied by the portion of ensilage in the feed. In order to arrive at the amount which the fish farmer is willing to pay for ensilage (E, B, and M), the figure in the table must be divided by F and by the mixture. In the case of farming facilities of 8,000 m³, the fish farmer is consequently willing to pay up to N.Kr. 0.865 per kg of ensilage, when the alternative is to use frozen capelin for wet feed at a cost of N.Kr. 1.50 per kg of capelin. In the case of facilities of 3,000 m³, the corresponding figure is 1.085. See Table XVIII. 25

If we compare the above figures with the full cost of ensilage (see Paragraph 3.4), it is evident that an ensilage facility can count on a good profit margin when selling ensilage to fish farming facilities with a capacity of 3,000 m³. When selling ensilage to facilities of 8,000 m³, the fish farmer is not willing to pay as much as the full cost of producing ensilage at the ensilage facility. The difference is minimal, however; only (888.6/1,000 - 0.865) = N.Kr. 0.021 per kg. See Paragraph 10.

5 MAXIMUM PRICE OF CAPELIN

A farming facility of 8,000 m³ is willing to pay less for ensilage than is a facility of 3,000 m³. In my calculations, I assume that the ensilage facility does not practice any discrimination with regard to pricing. The price which a facility of 8,000 m³ is willing to pay thus equals the maximum price of ensilage. If the selling price equals the maximum price, with a profit margin of 0%, we may arrive at the maximum price to be paid for

fresh capelin by means of the full cost calculation for the ensilage facility. It is assumed that frozen capelin costs N.Kr. 1.50 per kg. The full cost calculation is shown in Table 6.

Table 6. Full cost calculation for the ensilage facility when frozen capelin costs N.Kr. 1.50 pr kg, and when the selling price is set at a maximum and equals that price at which the fish farmer is indifferent in his choice between frozen capelin for wet feed and ensilage for acidic feed. 26

COSTS	TOTAL COSTS E	UNIT COSTS E
VARIABLE COSTS		
Capelin, maximum price	1,966,040	427.4
Acid	694,600	151.0
Wages	35,728	7.8
Electricity consumption	4,867	1.1
Maintenance/repairs	126,940	27.6
Distribution	460,000	100.0
SUM OF VARIABLE COSTS	3,288,175	714.9
FIXED EXPENSES		
Write-offs	476,025	103.5
Interest payments	214,211	46.6
SUM OF FIXED EXPENSES	690,236	150.1
FULL COST	3,978,411	865.0
PROFIT	0	0.0
MAXIMUM SELLING PRICE	3,978,411	865.0

One may consequently expect to pay per kg of capelin:

Maximum price of capelin for E: (427.4/0.974 x 1,000) = N.Kr. 0.439

6 HEAT-TREATED ENSILAGE

27

As mentioned in the introduction, it is enough to mix in 15% of a binding agent in the ensilage provided that the ensilage is heat-treated beforehand. This is due to the fact that the enzymes causing autolysis are inactivated when heated. The heat treatment may be administered in two ways:

-Ensiling process and heat treatment - indicated by "B".
-Heat treatment and lactic acid fermentation - indicated by "M".

6.1 PRODUCTION VOLUME

The feed factor is calculated in the same manner as shown for E in paragraph 3.1. The composition of the two types of heat treated ensilage is as follows:

B: Capelin 97.4%; formic acid 2.5%; and sorbic acid 0.1%. The content of energy in the ensilage is 0.974 multiplied by the content of energy in capelin.

M: Capelin 97.7%; formic acid 0.7%; sorbic acid 0.1%; and molasses 1.5%. The ensilage has a content of energy of 0.977 multiplied by the content of energy in capelin.

If the content of energy in the binding agent is 12.6 MJ OE and the content of energy in capelin is 6.8 MJ OE, F may be expressed as follows: F_B=2.99 and F_M=2.99

The production volume corresponding to a certain quantity of fish produced is calculated in the same way as the production volume of E. As was the case in my calculations for E, I am also here using only one decimal in the feed factor when calculating the volume of production. Since the feed factor is the same for B and M, the volume of production corresponding to a quantity of 4,000 tons of fish produced will also be the same. The volume of production is therefore:

Number of tons of heat treated ensilage = (4,000 x 3.0 x 0.85)= 10,200 tons. 28

This is therefore the correct volume of production to compare with each other and with E and V.

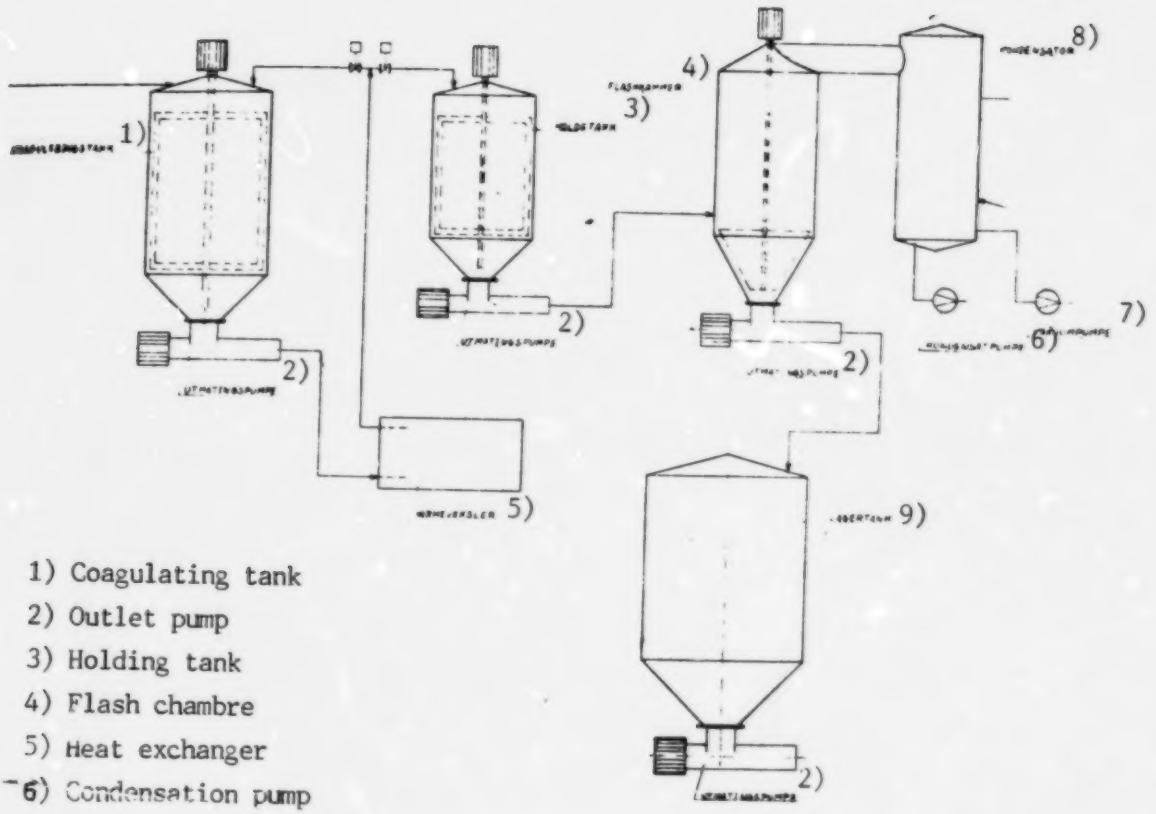
6.2 INVESTMENTS FOR THE ENSILAGE FACILITY

As with E, it is assumed that the processing equipment may be placed in already existing buildings. The purchase of equipment for unloading (Netzsch N150 mono-pump), measuring (Brødr. Hetland HMK 100-2 measuring device) and further transportation of the volume of capelin (Netzsch NES 150A mono-pump) will be the same as for ordinary ensilage. See paragraph 3.2.1. The same applies to the intermediate storage tanks of 600 m³.

6.2.1 Processing Equipment for Ensilage and Heat Treatment - Process B

Landteknikk A/L in Trondheim sells a so-called Flow Therm Processer for the heat-treating of capelin. Having ensiled the volume of capelin with the Hamjern equipment as shown in Paragraph 3.2.2, the ensilage is heat treated by means of the Flow Therm Process. The heat treating apparatus is shown in Figure 6.

From the ensilage facility, the capelin is pumped to a coagulation tank. By recirculating the capelin via a heat exchanger, the temperature of the mixture in the coagulation tank reaches 85°C, whereas the recirculated product stays at 95°C. From the heat exchanger the capelin proceeds to a holding tank where the desired temperature is kept as long as it is wanted. The temperature is then lowered to 25°C in a flash chambre. After this the ensilage proceeds to the storage facility. The capacity of the heat treating installation is three tons an hour, and 325 kw are consumed per hour (Myrland, 1983). The installation, including a storage tank of 20 m^3, costs N.Kr. 1,415,300 (Ibid.). Without the storage tank which costs approximately N.Kr. 30,000 (Myrland, pers. com.), the equipment will cost about N.Kr. 1,385,000. A receiver/raw material grinder/pump is included in the price. This item is not necessary, however. This means that the price will be reduced 29 by an additional N.Kr. 70,000 (Isaksen, pers. com.) if this item is removed. The total investment cost is thus N.Kr. 1,315,000 fully installed in Tromsø. In addition, there are the costs of Hamjern's ensilage equipment, totalling approximately 1,527,000 plus the storage tank.



1) Coagulating tank
2) Outlet pump
3) Holding tank
4) Flash chambre
5) Heat exchanger
6) Condensation pump
7) Vacuum pump
8) Condensator
9) Storage tank

Figure 6. Landteknikk's Flow Therm Processor for the heat treatment of capelin ensilage, including a storage tank (one piece). The ensilage from Hamjern's ensilage installation is introduced on the left hand side, and the receiving grinder and pump which are originally part of the equipment from Landteknikk, have been removed (Myrland, 1983).

It is assumed that a storage capacity of 400 m^3 is necessary, and sufficient, for an annual production of 10,200 tons of heat treated ensilage. It is further assumed that the equipment is capable of receiving 600 tons of capelin per load. Landteknikk also supplies storage tanks. A standing non-insulated tank

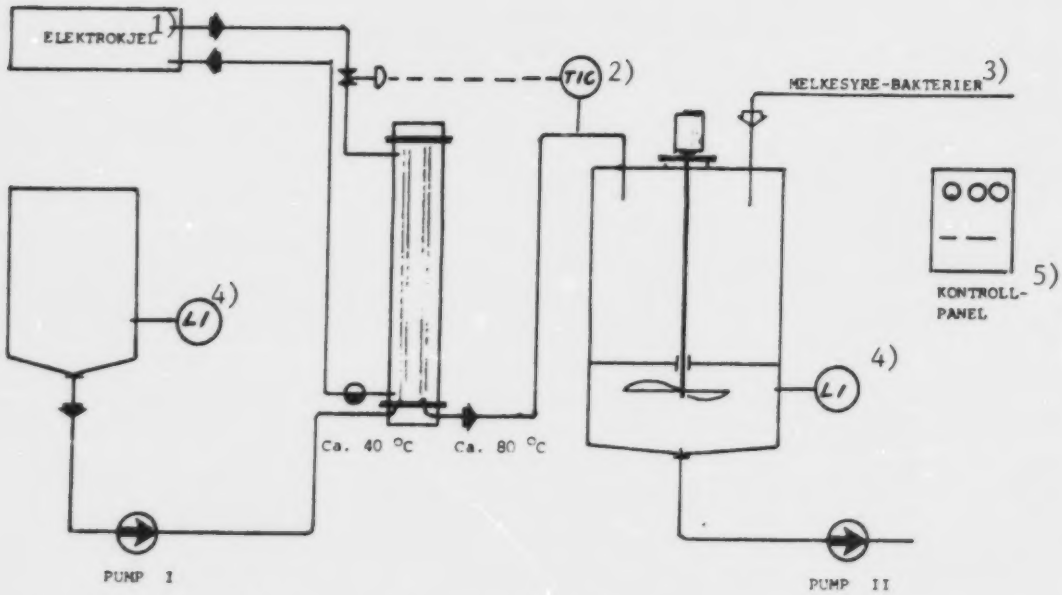
of 100 m³ costs N.Kr. 156,000 (Myrland, pers. com.). That is N.Kr. 1.56 per litre of volume. When adding N.Kr. 1.00 per litre for insulation (Sketch, -), the cost of the storage tank will be N.Kr. 1,024,000. 30

6.2.2 Processing Equipment for Heat Treatment and Lactic Acid Fermentation - Process M

Stord Bartz A.S of Bergen supplies equipment for the heat treatment and lactic acid ensilation of prepreserved capelin raw material. The installation is supplied with a capacity of one ton an hour or three tons an hour. The storage tank is supplied with an agitator. See Figures 7 and 8.

An installation with a capacity of one ton an hour will be too small for the production of 10,200 tons of ensilage per year, and the data presented here are for the larger of the two. For this type of ensilage, the capelin 31
is prepreserved in intermediate storage tanks by adding 0.7% formic acid and 1.5% molasses. (The volume of capelin does not pass through an ensilage facility of the Hamjern type prior to the heat treatment.) From the intermediate storage tanks the capelin proceeds to a vertical pipe heat exchanger with the help of a lobe-pump that has a capacity of three tons an hour. In the heat exchanger, the temperature rises to approximately 80°C. Then the product proceeds via a temperature regulating device of the heat exchanger to the storage tanks (Lowzow, 1983). Lactic acid bacteria are added in the storage tanks. These tanks are insulated so that they may be placed outdoors, and each tank is provided with an agitator which stirs the ensilage (Ibid.). This installation is automated.

30 cont.



Intermediate storage tank — For ensilage of a suitable consistency, including molasses

Heat exchanger

Storage tank

1) Electric steam boiler

2) Temperature regulator

3) Lactic acid bacteria

4) Level indicator

5) Control panel

Figure 7. Stord Bartz A.S installation for the heat treatment and lactic acid ensilation of pre-preserved capelin raw material. The Figure shows an installation with a capacity of one ton, and with one storage tank. (Somewhat different from the equipment supplied (Lowzow, 1983).)

31
cont.

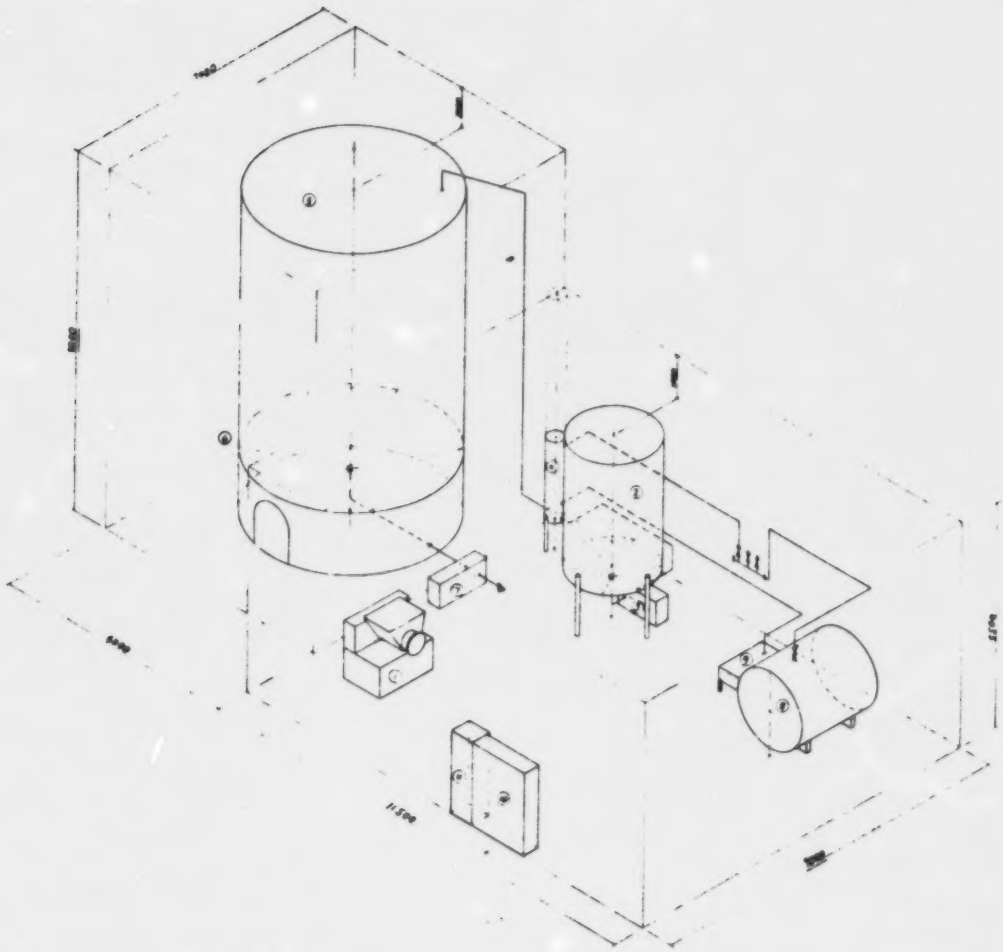


Figure 8. Sketch of the Stord Bartz A.S installation with a capacity of one ton, and with one tank placed indoors (Lowzow, 1983).

The electricity consumption is 280 kw an hour (Utvik, pers. com.). This estimate includes two agitators of four kw each. With a storage capacity of 400 m^3, an additional two agitators are in operation. This gives a total of 288 kw. 32

The price of a three ton facility from Stord Bartz A.S is N.Kr. 1,340,000 plus N.Kr. 31,000 for the insulation casing, and approximately N.Kr. 160,000 to have the facility installed (Lowzow, 1983). In addition, there will be

a cost of N.Kr. 15,000 to have the equipment shipped from Bergen to Tromsø (Evanger, pers. com.). This all produces a total of approximately N.Kr. 1,546,000 when two tanks of 100 m^3 each are included. The processing equipment itself costs approximately N.Kr. 816,000 excluding the costs of a 10 m^3 intermediate tank, two storage tanks of 100 m^3, shipping, insulation casing, and installation. See Appendix 3.

A storage capacity of 100 m^3, including shipping, insulation casing, and installation costs, thus amounts to (697,000/2) = N.Kr. 348,500. In my calculations, I take it as a given that this will be the price per 100 m^3 facility when more than one tank is involved. The cost of a 400 m^3 facility will consequently be (348,500 x 4) = N.Kr. 1,394,000. These figures are approximations. The design of the agitators especially may result in considerable variations in price (Ibid.).

6.3 INVESTMENTS, WRITE-OFFS, AND INTEREST PAYMENTS

When adding a 10% investment tax to the purchases including shipping and installation, the investment costs will be as shown in Table 7. See also Table I.

As was the case with E, I assume that the choice is to insulate the storage 33
tank for being placed outdoors rather than to build a structure around it. By using the same formulas for write-offs and interest payments as were used for E, the write-offs will be N.Kr. 693,000 for B and N.Kr. 636,735 for M, and the interest payments will amount to N.Kr. 311,850 for B and

N.Kr. 286,531 for M. Having an annual production of 10,200 tons of heat treated ensilage, the cost of write-offs per ton will be N.Kr. 67.9 and N.Kr. 62.4 for B and M respectively. The interest payments per ton will be N.Kr. 30.6 for B and N.Kr. 28.1 for M. This is shown in Table II.

Table 7. Total cost of investments in connection with an ensilage/ heat treating facility

ITEMS TO BE PURCHASED	TOTAL INVESTMENT B	M
Netzsch N150 mono-pump	250,000	250,000
HMK 100-2 rotating measuring device	228,000	228,000
Netzsch NES 150A pump	235,000	235,000
Intermediate storage tanks capacity 600 m^3	936,000	936,000
Hamjern processing equipment	212,000	-
Landteknikk Flow-Therm processing equipment	1,325,000	-
Stord Bartz A.S processing equipment	-	816,000
Storage tank of 400 m^3	1,024,000	1,394,000
SUBTOTAL	4,200,000	3,859,000
10% investment tax	420,000	385,900
Total investment costs	4,620,000	4,244,900

6.4 OPERATING COSTS

The cost of maintenance and repairs is calculated in the same way as for E and is shown in Table III.

The wages are calculated on the basis of the assumption that heat treated ensilage (B) contains 97.4% capelin, whereas heat treated and lactic acid fermented ensilage (M) contains 97.7% capelin.

B: Unloading facility: $(\frac{10,200 \times 0.974 \times 1/0.97}{210} 72) = \text{NKr. } 3,512$ 34

Ensilage/heat treatment: $(\frac{10,200 \times 1/0.97}{3} 72) = \text{N.Kr } 252,371$

N.Kr 255,883

This equals per ton of ensilage (255,883/10,200)=N.Kr. 25.1 per ton

M: Unloading facility: $(\frac{10,200 \times 0.977 \times 1/0.97}{210} 72) = \text{NKr. } 3,522$

Heat treatment/ Lactic acid ensilation: $(\frac{10,200 \times 1/0.97}{3} 72) = \text{N.Kr. } 252,371$

N.Kr. 255,893

This equals per ton of ensilage (255,893/10,200) = N.Kr. 25.1 per ton

When the price of formic acid is N.Kr. 5.44 per kg, and the price of sorbic acid is N.Kr. 15 per kg, the cost of acid will be:

B: Total: $(\frac{10,200,000 \times 2.5}{100} 5.44 + \frac{10,200,000 \times 0.1}{100} 15) = \text{N.Kr. } 1,540,000$

Per ton of ensilage: (1,540,000/10,200) = N.Kr. 151.0

M: Total: $(\frac{10,200,000 \times 0.7}{100} 5.44 + \frac{10,200,000 \times 0.1}{100} 15) = \text{N.Kr. } 541,416$

Per ton of ensilage: (541,416/10,200) = N.Kr. 53.1

In order to produce lactic acid fermented ensilage it is necessary to add 1.5% molasses. Molasses costs N.Kr. 2.50 per kg (Raa, pers. com.). This equals:

M: Total: $(\frac{10,200,000 \times 1.5}{100} 2.50) =$ N.Kr. 382.500

Per ton of ensilage: $(382,500/10,200^{*}) =$ N.Kr. 37.5

The distribution costs are the same as for E. At a cost of N.Kr. 100 per ton, the distribution costs will total N.Kr. 1,020,000 for B as well as for M.

It is assumed that the agitators in M will be in operation for about the same length of time as the processing equipment. It is further assumed that the ensilage facility is in operation for three tenths of the total period of operation in B.

Consumption of electricity: 35

Unloading facility:	(75+3+75) = 153 kw
Ensilage facility:	35 kw
Flow-Therm process:	325 kw
Stord Bartz Processor with agitators:	(272+16) = 288 kw

The number of hours of operation per year is:

Unloading facility B:	$(\frac{10,200 \times 0.974 \times 1/0.97}{210}) =$	49 hours
Unloading facility M:	$(\frac{10,200 \times).977 \times 1/0.97}{210}) =$	49 hours
Ensilage facility B:	(10,200/10) =	1,020 hours
Heat treating facility:	(10,200/3) =	3,400 hours
Heat treating and lactic acid ensilage facility M:	(10,200/3) =	3,400 hours

* Translator's footnote: The figure 10,200 not in original. Must be an error.

The cost of electricity is thus a total of N.Kr. 287,049 for B and N.Kr. 246,674 for M, or N.Kr. 28.1 and N.Kr. 24.2 per ton of ensilage for B and M respectively. See Table IV.

When taking into account the market price of capelin (N.Kr. 460 per ton), the cost of capelin is as follows:

B: Total:	(10,200 x 0.974 x 460)	= N.Kr.	4,570,008
Per ton of ensilage:	(460 x 0.974)	= N.Kr.	448.0
M: Total:	(10,200 x 0.977 x 460)	= N.Kr.	4,584,084
Per ton of ensilage:	(460 x 0.977)	= N.Kr.	449.4

6.5 FULL COST CALCULATION OF ENSILATION/HEAT TREATMENT

The above costs are sufficient to establish a full cost calculation for the ensilation and heat treatment of capelin raw material. The cost of lactic acid bacteria is excluded. The unit cost is indicated per ton of finished ensilage. See Table 8. See also Table V.

If the market price of capelin is N.Kr. 460 per ton, the calculation below (Table 8) will constitute the likely estimate of the full cost involved. 36

Table 8: Full cost calculation for the production of heat treated ensilage (B) and heat treated and lactic acid fermented ensilage (M) when the price of capelin is the market price and the cost of lactic acid bacteria equals "m" per ton of ensilage.

COSTS	TOTAL COSTS		UNIT COSTS	
	B	M	B	M
VARIABLE COSTS:				
Capelin	4,570,008	4,584,084	448.0	449.4
Acid	1,540,000	541,416	151.0	53.1
Molasses	-	382,500	-	37.5
Lactid acid bacteria	-	m_T	-	m
Wages	255,883	255,893	25.1	25.1
Consumption of electricity	287,049	246,674	28.1	24.2
Maintenance/repairs	184,800	169,796	18.1	16.6
Distribution	1,020,000	1,020,000	100.0	100.0
SUM OF VARIABLE COSTS	7,857,740	7,200,363 $+m_T$	770.3	705.9 +m
FIXED EXPENSES:				
Write-offs	693,000	636,735	67.9	62.4
Interest payments	311,850	286,531	30.6	28.1
SUM OF FIXED EXPENSES	1,004,850	923,266	98.5	90.5
FULL COST=TOTAL COSTS	8,862,590	8,123,629 $+m_T$	868.8	796.4 +m

6.6 FULL COST OF PRODUCTION OF ENSILED/HEAT TREATED CAPELIN RAW MATERIAL

A full cost calculation for the production of fish feed from heat treated ensilage may be set up in the same manner as was done in the case of E. By setting the total costs (= full cost per kg of salmon) for the other types of feed as equal to the full cost of wet feed, that price of heat treated ensilage may be found at which the fish farmer is indifferent in his choice of using this type of ensilage for acidic feed or frozen capelin for wet feed. This price of heat treated ensilage (B and M) is being used in the full cost calculation shown in Table 9. See also Table XVII.

The cost of the capelin/heat treated ensilage divided by F and the mixed-in capelin/ensilage, produces the price which the fish farmer will be willing to pay for heat treated ensilage. This figure will be the same for B as well as for M. If the price of frozen capelin is N.Kr. 1.50 per kg, the fish farmer of an 8,000 m^3 farming facility will be willing to pay up to N.Kr. 1.553 per kg for heat treated ensilage of either type. The fish farmer at a 3,000 m^3 facility will be willing to pay more: up to N.Kr. 1.612. Cf. Table XVIII. Both of these figures are considerably higher than the full cost figures of the ensilage facility (Table 8). 37

Table 8. Full cost calculation for the production of wet feed and acidic feed at a fish farming facility where the price of B and M has been determined in such a way that the full cost of V = the full cost of B = the full cost of M (per kg of salmon).

COSTS	TOTAL COSTS				PER KG OF SALMON			
	3,000 m³		8,000 m³		3,000m³		8,000m³	
	V	B=M	V	B=M	V	B=M	V	B=M
VARIABLE COSTS								
Frozen capelin	285,120	-	760,320	-	4.752	-	4.752	-
Heat treated ensilage	-	245,804	-	631,717	-	4.096	-	3.948
Binding agent	100,320	127,823	267,520	340,860	1.672	2.130	1.672	2.130
Maintenance/ repairs	14,956	17,013	20,764	29,403	0.249	0.284	0.130	0.184
Wages	27,544	16,478	40,451	27,441	0.459	0.275	0.253	0.172
Electricity for equipment	1,214	815	3,237	2,174	0.020	0.014	0.020	0.014
SUM OF VARIABLE COSTS	429,154	407,933	1,092,292	1,031,595	7.152	6.799	6.827	6.448
FIXED EXPENSES								
Write-offs	39,567	63,797	51,183	110,261	0.659	1.063	0.320	0.689
Interest payments	25,238	28,709	35,039	49,618	0.421	0.478	0.219	0.310
Electricity for freezer rooms	6,480	-	12,960	-	0.108	-	0.081	-
SUM OF FIXED EXPENSES	71,285	92,506	99,182	159,879	1.188	1.541	0.620	0.999
FULL COST	500,439	500,439	1,191,474	1,191,474	8.340	8.340	7.447	7.447

6.7 MAXIMUM PRICE OF CAPELIN

An 8,000 m³ facility is also willing to pay less for heat treated ensilage than is a 3,000 m³ facility. Assuming that the ensilage facility does not practice any discrimination with regard to prices, the maximum price per kg of heat treated ensilage will be N.Kr. 1.553. This means that there is a profit of 0%. By using the full cost calculation for the ensilage facility, 38
as was done in the case of E, the maximum price to be paid for fresh capelin may be arrived at, given that frozen capelin costs N.Kr. 1.50 per kg. The full cost calculation is shown in Table 10. (See also Table XIX.) It is assumed that the fish farmer is willing to pay the same amount per kg of capelin for heat treatment and ensilation according to method M as according to method B. Capelin for one ton of ensilage may then cost:

Maximum price of capelin M: (1,132.2 x 977/974) = N.Kr. 1,137.7

The cost of lactic acid bacteria will then be:

m = lactic acid bacteria = (1,206.0 - 1,135.7) = N.Kr. 70.3 39

One can thus pay N.Kr. 70.3 for lactic acid bacteria per ton of ensilage.

One may than be willing to pay per kg of capelin:

Maximum price of capelin for B: (1,132.2/0.974*x1,000) = N.Kr. 1.162

Maximum price of capelin for M: (1,135.7/0.977x1,000) = N.Kr. 1.162

* Translator's footnote: original text has .0974. That must be an error.

Table 10. Full cost calculation for an ensilage facility when frozen capelin costs N.Kr. 1.50 per kg, and when the selling price is the maximum price and equals that price at which the fish farmer is indifferent in his choice between frozen capelin for wet feed and heat treated ensilage for acidic feed. 38 cont.

COSTS	TOTAL COSTS		UNIT COSTS	
	B	M	B	M
VARIABLE COSTS				
Capelin, maximum price	11,548,440	12,301,200 $-m_T$	1,132.2	1,206.0 -m
Acid	1,540,000	541,416	151.0	53.1
Molasses	-	382,500	-	37.5
Lactic acid bacteria	-	m_T	-	m
Wages	255,883	255,893	25.1	25.1
Electricity consumption	287,049	246,674	28.1	24.1
Maintenance/repairs	184,800	169,796	18.1	16.6
Distribution	1,020,000	1,020,000	100.0	100.0
SUM OF VARIABLE COSTS	14,836,172	14,917,479	1,454.5	1,462.5
FIXED EXPENSES				
Write-offs	693,000	636,735	67.9	62.4
Interest payments	311,850	286,531	30.6	28.1
SUM OF FIXED EXPENSES	1,004,850	923,266	98.5	90.5
FULL COST	15,841,022	15,840,745	1,553.0	1,553.0
PROFIT	0	0	0.0	0.0
MAXIMUM SALES PRICE	15,841,022	15,840,745	1,553.0	1,553.0

7. MAXIMUM PRICE OF CAPELIN AND VARIATIONS IN FUNDAMENTAL FACTORS 39 cor

7.1 VARIATIONS IN PROFIT

It is assumed that the price of lactic acid bacteria is N.Kr. 70.3 per ton of ensilage in M. It is further assumed that the sales price is the maximum price and that the other costs are as those indicated in Table XIX. The maximum price that one is willing to pay for one kg of capelin while taking into account various requirements for profit, is indicated in the following equations: (P = price per kg; π = profit in percentages.)

$$E: \quad 974P_E + (865.0-427.4) + \frac{(974P_E+(865.0-427.4))\pi}{100} = 865.0$$

This is roughly, with regard to P_E: $\quad P_E = \frac{42740 - 437.6\pi}{974(100+\pi)}$

$$B: \quad 974P_B + (1553.0-1132.2) + \frac{(974P_B+(1553.0-1132.2))\pi}{100} = 1553.0$$

This is roughly, with regard to P_B: $\quad P_B = \frac{113220 - 420.8\pi}{974(100+\pi)}$

$$M: \quad 977P_M + (1553.0-1135.7) + \frac{(977P_M+(1553.0-1135.7))\pi}{100} = 1553.0$$

This is roughly, with regard to P_M: $\quad P_M = \frac{113570 - 417.3\pi}{977(100+\pi)}$

By plotting the percentages of profit against that which one is willing to pay for capelin, the correlation shown in Figure 9 emerges: 40

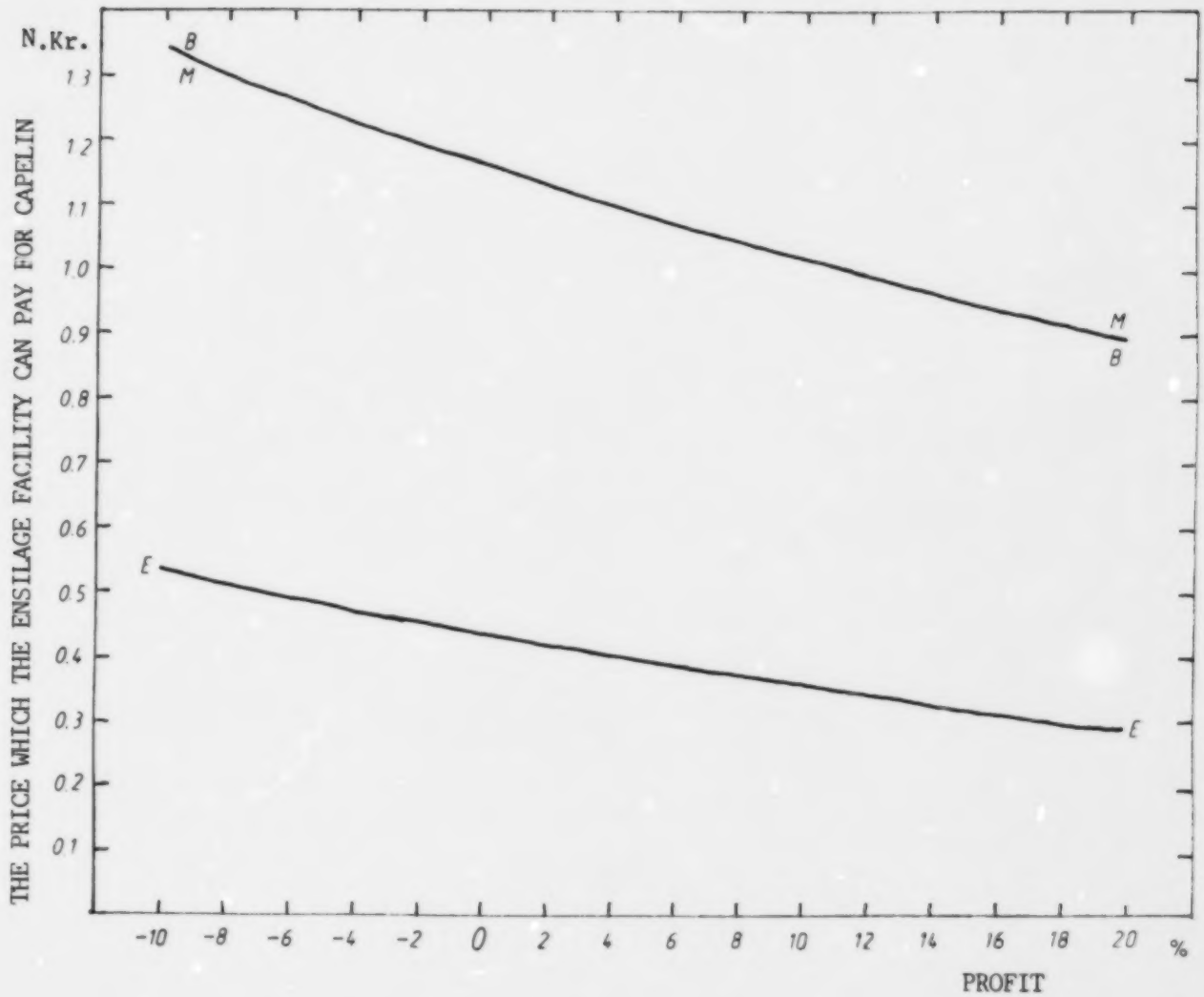


Figure 9. The connection between the percentage of profit and the price which the ensilage facility is willing to pay for capelin when the price of frozen capelin is N.Kr. 1.50 per kg, when the fish farmer is indifferent, and when the cost of lactic acid bacteria is N.Kr. 70.3 per ton of ensilage in M.

The figure shows that with a profit of zero percent, E is somewhat below 41
the market price for capelin, a fact which was demonstrated earlier. B and M are considerably above the market price, even with a profit of 20%. The lower the profit is, the more sensitive that price is which the ensilage facility is able to pay for capelin, in terms of changes in the amount of profit desired by the ensilage facility.

7.2 VARIATIONS IN DISTRIBUTION COSTS

A profit of zero percent is assumed. It is further assumed that the cost of lactic acid bacteria in M is N.Kr. 70.3 per ton of ensilage. The prices which one would be willing to pay for one kg of capelin are indicated in the following equations: (P = price per kg; D = distribution costs per ton of ensilage.)

$$E: \quad 865{,}0 = 974P_E + D + (865.0-427.4-100)$$

$$P_E = \frac{527{,}4-D}{974}$$

$$B: \quad 1553.0 = 974P_B + D + (1553.0-1132.2-100)$$

$$P_B = \frac{1232.2-D}{974}$$

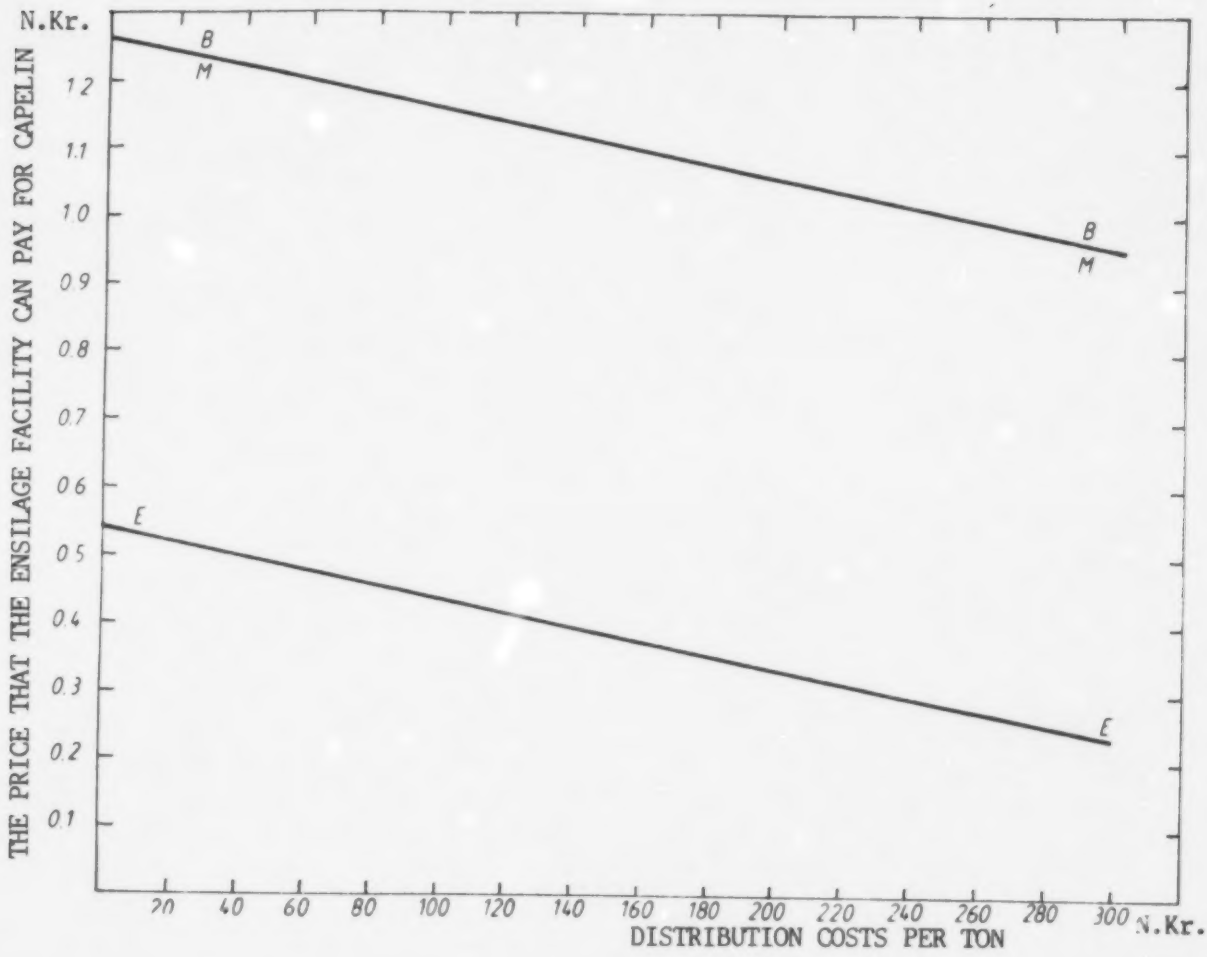
$$M: \quad 1553.0 = 977P_M + D + (1553.0-1135.7-100)$$

$$P_M = \frac{1235{,}7-D}{977}$$

The correlation is shown in Figure 10.

The correlation is linear. The differences in the angle coefficients are insignificant (-1/974 for E and B; -1/977 for M), and changes in the

distribution cost will have about the same impact in all three cases. A change in the distribution costs of N.Kr. 20 per ton, equalling N.Kr. 0.020 per kg, will produce a change in the price of capelin of N.Kr. 0.021 per kg for E and B, and N.Kr. 0.020 for M. With a trucking tariff of N.Kr. 220 per ton, the results would be: P_E = N.Kr. 0.316 per kg, P_B = N.Kr. 1.039 per kg, and P_M = N.Kr. 1.040 per kg. When setting the distribution costs at approximately N.Kr. 79 per ton, P_E is at the level of the market price for capelin.



42

Fig. 10. The price which the ensilage facility can pay for capelin to be used for ensilage, at various distribution costs.

7.3 VARIATIONS IN PRODUCTION

A profit of zero percent is assumed. It is further assumed that frozen capelin costs N.Kr. 1.50 per kg, that the average content of energy in the capelin is 6.8 MJ OE per kg capelin, and that the price of lactic acid bacteria is N.Kr. 70.3 per ton of ensilage. (P = price per kg; q = quantity produced.)

The variable unit costs per ton, AVC, will be:

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$$AVC_E = 714.9 - 427.4 \cdot 974P_E = 287.5 \cdot 974P_E$$

$$AVC_B = 1454.5 - 1132.2 \cdot 974P_B = 322.3 \cdot 974P_B$$

$$AVC_M = 1462.5 - 1135.7 \cdot 977P_M = 326.8 \cdot 977P_M$$

The fixed unit costs per ton, AFC, will thus be:

$$AFC_E = 150.1 \cdot 4600/q = 690460/q$$

$$AFC_B = 98.5 \cdot 10200/q = 1004700/q$$

$$AFC_M = 90.5 \cdot 10200/q = 923100/q$$

If we add AVC and AFC, ATC is arrived at, i.e. the full cost in relation to q, expressed as P_E, P_B, and P_M. The full cost equals 865 in the case of E, and 1553 in the case of B and M. The following three equations express the maximum price that the ensilage facility can pay for capelin, as a function of quantity = q:

$$E: \quad 865.0 = \frac{690460}{q} + 287.5 + 974P_E$$

$$P_E = 0.593 - \frac{690460}{974q}$$

$$B: \quad 1553.0 = \frac{1004700}{q} + 322,3 + 974P_B$$

$$P_B = 1.264 - \frac{1004700}{974q}$$

$$M: \quad 1553.0 = \frac{923100}{q} + 326.8 + 977P_M$$

$$P_M = 1.255 - \frac{923100}{977q}$$

The correlation between the quantity produced and the price which the ensilage facility is willing to pay for capelin is shown in Figure 11.

The curves for B and M are remarkably similar. In the case of low production levels, one might pay a little bit more in M than in B for capelin. The situation is reversed, albeit to a lesser degree, when production levels are increased. At the current level of production, approximately 10,200 tons, the situation is stable. It would take a large decrease of production if P_B and P_M were to change significantly. As far as E is concerned, there would be some advantage in increasing the level of production. If the level of 44
production were increased to 5,300 tons annually, one could pay a market price of approximately N.Kr. 0.46 per kg, and a production of 8,000 tons per year would produce a P_E of more than N.Kr. 0.50. A decreased production, however, would cause the P_E to quickly drop even further. The situation is therefore considerably less stable in the case of E.

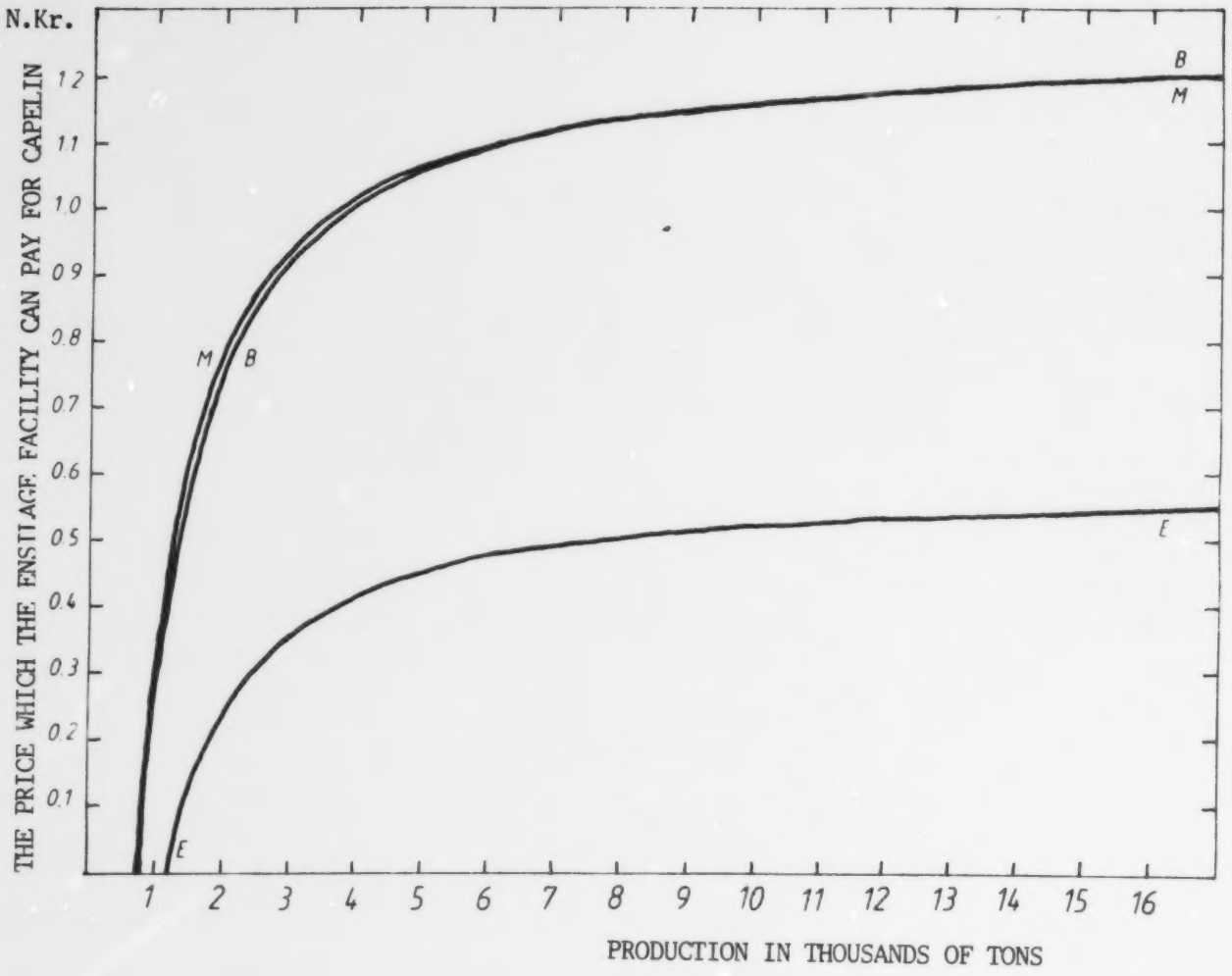

Fig. 11. The price which the ensilage facility is willing to pay for capelin at various levels of production.

7.4 VARIATIONS IN THE PRICE OF FROZEN CAPELIN

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The price of frozen capelin is fixed, regardless of the time of year that the capelin is caught. There was an exception in the spring of 1983, when the price dropped by N.Kr. 0.05 per kg at the end of February, from N.Kr. 1.35 to N.Kr. 1.30 per kg (Ingebrigtsen, pers. com.). The drop in price was due

to market conditions and had nothing to do with the content of energy in capelin (Ibid.). Cf. paragraph 4.3.6. For the fish farmer, the price can reach N.Kr. 1.80 per kg (Sørensen, 1983)., perhaps even higher. Given that the average content of energy is still 6.8 MJ OE per kg of frozen capelin, that the price of frozen capelin is P_V per kg, and that the price of the various types of ensilage is P_E, P_M, and P_M respectively per kg, the cost of capelin in an 8,000 m³ facility will be as shown in Appendix 4.

On the basis of the above, the full cost per kg of salmon may be calculated (Appendix 4). In order that the fish farmer may be indifferent, the full cost of the production of ensilage must equal the full cost of V. By means of P_V we may thus express that amount which the fish farmer is willing to pay for ensilage. (See Appendix 4.)

If we equate the amount which the fish farmer is willing to pay for ensilage (per ton), expressed as P_V, to the full cost of the ensilage facility, expressed as P_E, P_B, and P_M, we may arrive at the maximum price which the ensilage facility is willing to pay for capelin for ensilation/ensilation and heat treatment, expressed as the price of frozen capelin. A profit of zero percent is assumed, as well as distribution costs of N.Kr. 100 per ton, and a cost of lactid acid bacteria in M of N.Kr. 70.3 per ton of ensilage.

E: $$\frac{3168p_V - 3740}{1.170} = 974P_E + (865.0-427.4)$$

$$P_E = \frac{3168p_V - 4252.0}{1139.6}$$

B: $$\frac{3168p_V - 804}{2.542} = 974P_B + (1553.0-1132.2)$$

$$P_B = \frac{3168p_V - 1873.7}{2475.9}$$

M: $$\frac{3168p_V - 804}{2.542} = 977P_M + (1553.0-1135.7)$$

$$P_M = \frac{3168p_V - 1864.8}{2483.5}$$

The correlation is shown in Figure 12:

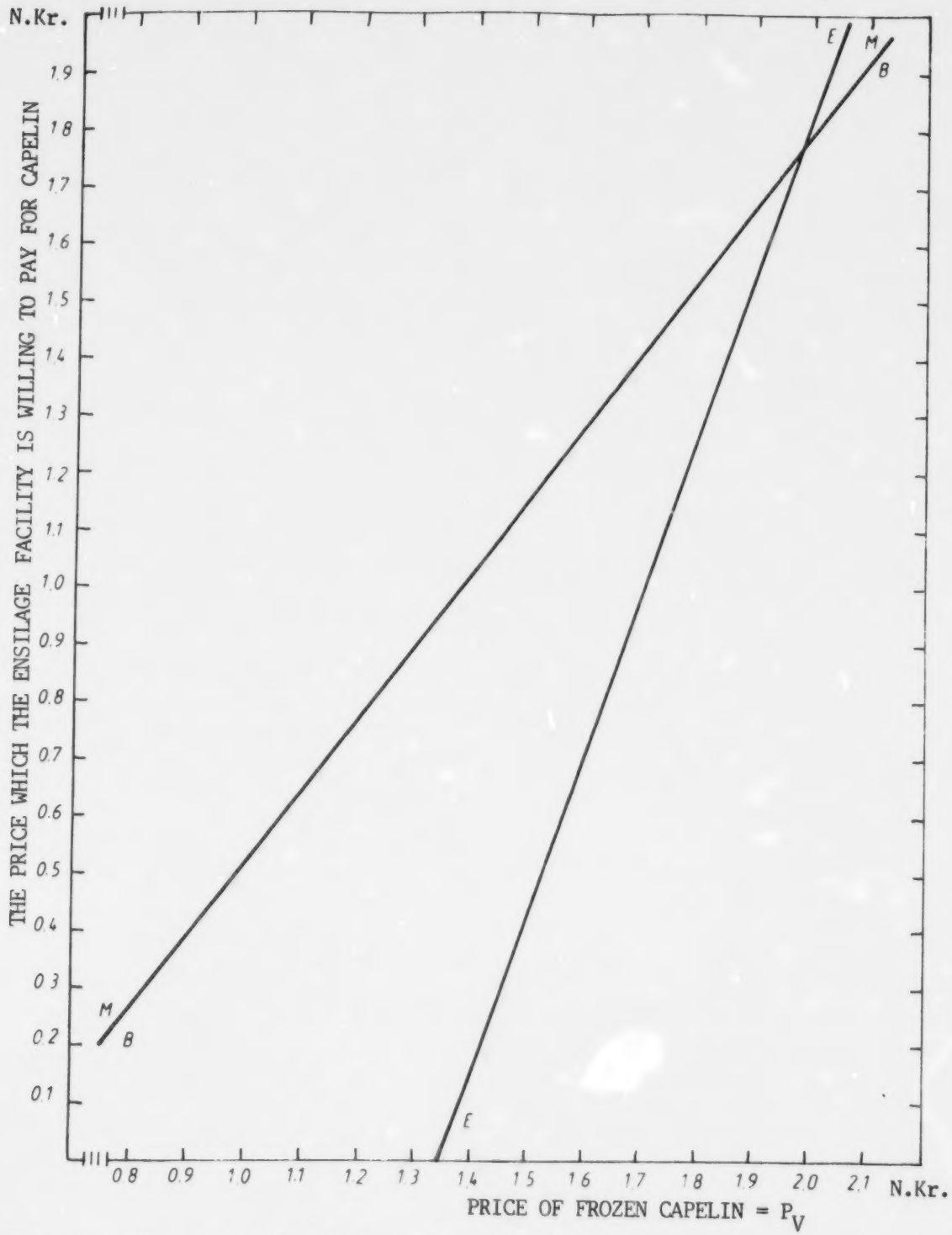

Fig. 12. The correlation between the price of frozen capelin and the maximum price that the ensilage facility is willing to pay for capelin.

The correlation is linear. As may be seen from the above figure, E is considerably more sensitive to variations in price of frozen capelin than are B or M. There is little difference between B and M. If P_V is changed by N.Kr. 0.20 per kg, P_E is changed by N.Kr. 0.556, P_B by N.Kr. 0.256, and P_M by N.Kr. 0.255. With regard to all types of ensilage, P is changed by a larger amount than the change occurring in P_V. When P_V = 1.508, E can pay N.Kr. 0.46 per kg of capelin. However, P_V has to drop to N.Kr. 0.951 and N.Kr. 0.949 per kg respectively, if B and M are not to pay more than the market price. 47

7.5 VARIATIONS IN THE FEED FACTOR

Given that the content of energy in the binding agent is constant, equalling 12.6 MJ OE per kg (Skretting, 1983-84), the feed factor depends on two things: 1) Loss of feed (indicated by S), and 2) The content of energy in Capelin (indicated by x). It is assumed that 13.5 MJ OE are required for the production of one kg of fish (Austreng, 1981). All costs in which the feed factor enters as a factor will therefore be influenced by a variation in S or x. In the case of the fish farmer, this applies to the following costs: feed (larger or smaller purchases of a binding agent and V, E, B, or M), wages (more or less work required), as well as consumption of electricity for the equipment (more or less work required). It is assumed that the cost of maintenance and repairs will not be effected to any significant degree. They have therefore been set as constant. That which the fish farmer will then be willing to pay for E, B, and M by being indifferent in his choice, will therefore determine the maximum price which the ensilage facility can

charge for their product, and the maximum amount that they will be willing to pay for capelin. The costs that are subject to change at the farming facility are shown in Tables XX to XXII.

We can now set up a full cost calculation in which the changed costs for feed are entered as a function of the feed factor, and with regard to the feed costs, also as a function of p. The calculations for a 3,000 m³ facility would be similar, but have not been included, because an 8,000 m³ facility is willing to pay the least and is therefore the more interesting one with respect to maximum prices.

Table 11. Full cost calculation for the farming facility, including variations in the feed factor as well as the price of frozen capelln and ensiled capelin. 48

COSTS	TOTAL COSTS				PER KG OF SALMON			
	V	E	B	M	V	E	B	M
VARIABLE COSTS:								
Feed costs V, E, B, M	$160000F_V$ × (P_V 0.9 + 4.75×0.1)	$160000F_E$ × (P_E 0.5 + 4.75×0.5)	$160000F_B$ × (P_B 0.85 + 4.75×0.15)	$160000F_M$ × (P_M 0.85 + 4.75×0.15)	F_V × (P_V 0.9 + 4.75×0.1)	F_E × (P_E 0.5 + 4.75×0.5)	F_B × (P_B 0.85 + 4.75×0.15)	F_M × (P_M 0.85 + 4.75×0.15)
Maint./repairs	20764	17845	29403	29403	0.130	0.112	0.184	0.184
Wages	$5867F_V$ + 19800	$5867F_E$ + 9900	$5867F_B$ + 9900	$5867F_M$ + 9900	$0.037F_V$ + 0.124	$0.037F_E$ + 0.062	$0.037F_B$ + 0.062	$0.037F_M$ + 0.062
Electr., equipm.	$920F_V$	$721F_E$	$721F_B$	$721F_M$	$0.006F_V$	$0.005F_E$	$0.005F_B$	$0.005F_M$
SUM OF VARIABLE COSTS	F_V(82787+ 144000P_V)+ 40564	F_E(386588+ 80000P_E)+ 27745	F_B(120588+ 136000P_B)+ 39303	F_M(120588+ 136000P_M)+ 39303	F_V(0.518+ 0.9P_V)+ 0.254	F_E(2.417+ 0.5P_E)+ 0.174	F_B(0.755+ 0.85P_B)+ 0.246	F_M(0.755+ 0.85P_M)+ 0.246
FIXED EXPENSES								
Write-offs	51183	66919	110261	110261	0.320	0.418	0.689	0.689
Interest payments	35039	30114	49618	49618	0.219	0.188	0.310	0.310
Elect., freezer	12960	-	-	-	0.081	-	-	-
SUM FIXED EXP.	99182	97033	159879	159879	0.620	0.606	0.999	0.999
FULL COST	F_V(82787+ 144000P_V)+ 139746	F_E(386588+ 80000P_E)+ 124778	F_B(120588+ 136000P_B)+ 199182	F_M(120588+ 136000P_M)+ 199182	F_V(0.518+ 0.9P_V)+ 0.874	F_E(2.417+ 0.5P_E)+ 0.780	F_B(0.755+ 0.85P_B)+ 1.245	F_M(0.755+ 0.85P_M)+ 1.245

We are now able to equate the full cost when using E, B, or M, to the full cost when using V, and we may now solve the equations with regard to p and have p expressed by means of the feed factor and p_V for E, B, and M.

$$E: \quad F_V(0.518+0.9p_V) + 0.874 = F_E(2.417+0.5p_E) + 0.780$$

$$p_E = \frac{F_V(1.036+1.8p_V) + 0,188}{F_E} - 4.834$$

$$B: \quad F_V(0.518+0.9p_V) + 0.874 = F_B(0.755+0.85p_B) + 1.245$$

$$p_B = \frac{F_V(0.609+1.059p_V) - 0.436}{F_B} - 0.888$$

$$M: \quad F_V(0.518+0.9p_V) + 0.874 = F_M(0.755+0.85p_M) + 1.245$$

$$p_M = \frac{F_V(0.609+1.059p_V) - 0.436}{F_M} - 0.888$$

The above equations express that which the fish farmer is willing to pay for one kg of ensilage when he is indifferent in his purchase of one kg of frozen capelin for the production of wet feed. The maximum price which the ensilage facility can pay for capelin, given the selling price ($\bar{p}$) and zero percent profit, will then be as follows:

$$E: \quad 1000p_E = 865 - 427,4 + 974P_E \qquad 49$$

$$\frac{F_V(1036+1800p_V)+188}{F_E} - 4834 = 437,6 + 974P_E$$

$$P_E = \frac{F_V(1036+1800p_V)+188}{974F_E} - 5,412$$

$$B: \quad 1000p_B = 1553 - 1132,2 +974P_B$$

$$\frac{F_V(609+1059p_V)-436}{F_B} - 888 = 420,8 + 974P_B$$

$$P_B = \frac{F_V(609+1059p_V)-436}{974F_B} - 1,344$$

M: $$1000p_M = 1553 - 1135.7 + 977P_M$$

$$\frac{F_V(609+1059p_V)-436}{F_M} - 888 = 417.3 + 977P_M$$

$$P_M = \frac{F_V(609+1059p_V)-436}{977F_M} - 1.336$$

7.5.1 Variations in Feed Loss

It is assumed the the content of energy in capelin is 6.8 MJ OE per kg. It is further assumed that the loss of feed is 8% higher when feeding wet feed than when using acidic feed. This percentage is an approximation. Compare losses of feed of approximately 40% and 48% (Karlsen, pers. com.). The loss of feed for ensilage is indicated by S. The loss of feed when using wet feed will then be (S+0.08), and the feed factors will be as follows:

$F_V = 13.5/(0.92-S)7.38$

$F_E = 13.5/(1-S)9.61$

$F_B = 13.5/(1-S)7.52$

$F_M = 13.5/(1-S)7.54$

When the figures for F are applied to the equations for P, we arrive at the price which the ensilage facility is willing to pay, when taking into account variations in loss of feed at the ensilage facility:

$$E: \quad P_E = \frac{(13.5/(0.92-S)7.38)(1036+1800p_V)+188}{974(13.5/(1-S)9.61} - 5.412$$

$$P_E = \frac{13.9S^2-(167.1+243.9p_V)S+243.9p_V+153.2}{93.2-101.4S} - 5.412$$

$$B: \quad P_B = \frac{(13,5/(0.92-S)7.38)(609+1059p_V)-436}{974(13.5/(1-S)7.52} - 1.344$$

$$P_B = \frac{-32.3S^2-(20.5+143.5p_V)S+143.5p_V+52.8}{119.2-129.5S} - 1.344$$

$$M: \quad P_M = \frac{(13.5/(0.92-S)7.38)(609+1059p_V)-436}{977(13.5/(1-S97.54} - 1.336$$

$$P_M = \frac{-32.3S^2-(20.5+143.5p_V)S+143.5p_V+52.8}{119.2-129.6S} - 1.336$$

The insertion of the desired p_V produces a function at which the price of capelin is expressed by the loss of feed at a constant content of energy. (The content of energy in frozen capelin equals the content of energy in ensiled capelin.) When setting the price of N.Kr. 1.80 as the upper limit for P_V and N.Kr. 1.30 as the lower limit, and P_V = N.Kr. 1.50, we arrive at the correlations between the loss of feed and that which the ensilage facility can pay for capelin. These correlations are shown in Figures 13 to 15.

When assuming a loss of feed of 40% for E,B, and M, when the loss of feed in the case of V is 48%, the values shown for P will be the same as previously indicated. As is evident from Figures 13 to 15, the price which the ensilage facility can pay for capelin increases with an increase in the loss of feed at the farming facilities. In other words, the higher the loss of feed, the more attractive is ensilage when compared to wet feed of frozen capelin. This is a particularly marked tendency in the case of E, whereas B and M are almost identical and rising gradually. By how much a change in percentage

in S has an impact on P depends on the size of S at the point of departure. I refer to the equations for P and to Figures 13 to 15. Nevertheless, as an approximation, we can say that, in the case of medium values for S, a change of 0.1 in S produces a change in P_E of about N.Kr. 0.2 per kg of capelin. In the case of higher values for S, the figures are considerably higher, and in the case of lower values for S, the figures are clearly lower. The tendency is similar in the case of P_B and P_M, only less so: a change of about N.Kr. 0.1 per kg capelin at medium values for S. As was evident from Figure 11, Figures 13 to 15 also show that P_B and P_M, and especially P_E, are sensitive to variations in p_V.

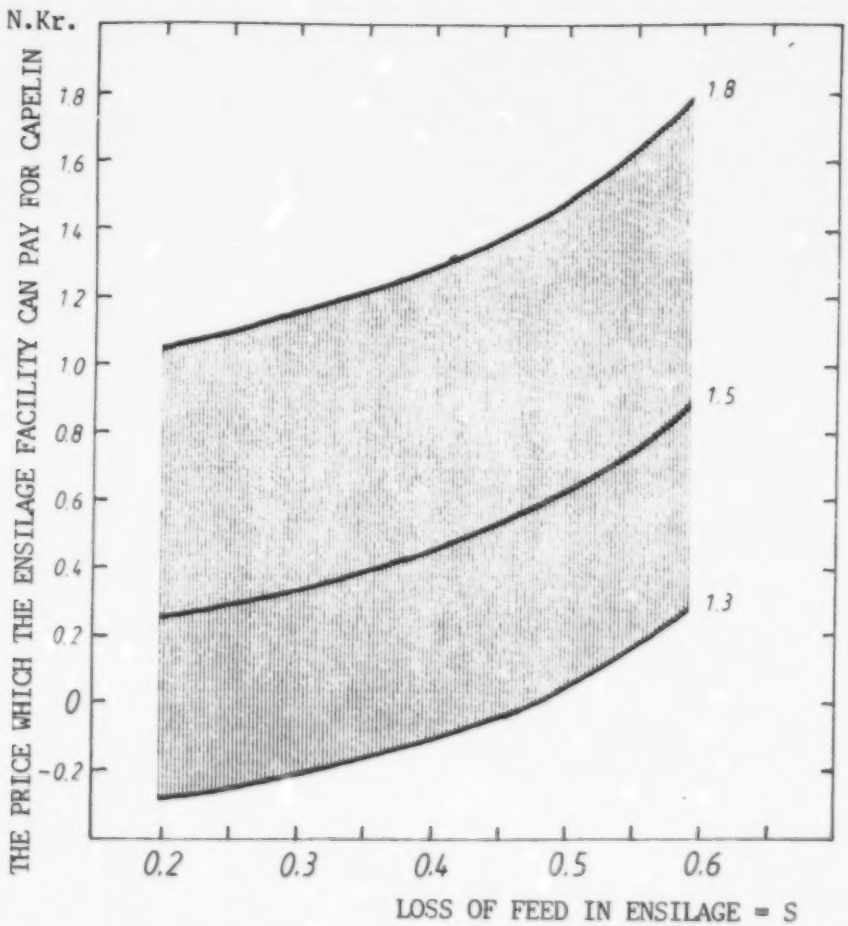

Fig. 13. The maximum price which the ensilage facility can pay for capelin for ensilage (E) when the loss of feed varies, when the loss of feed for wet feed is 8% higher than for acidic feed, and when the content of energy in capelin is 6.8 MJ OE per kg.

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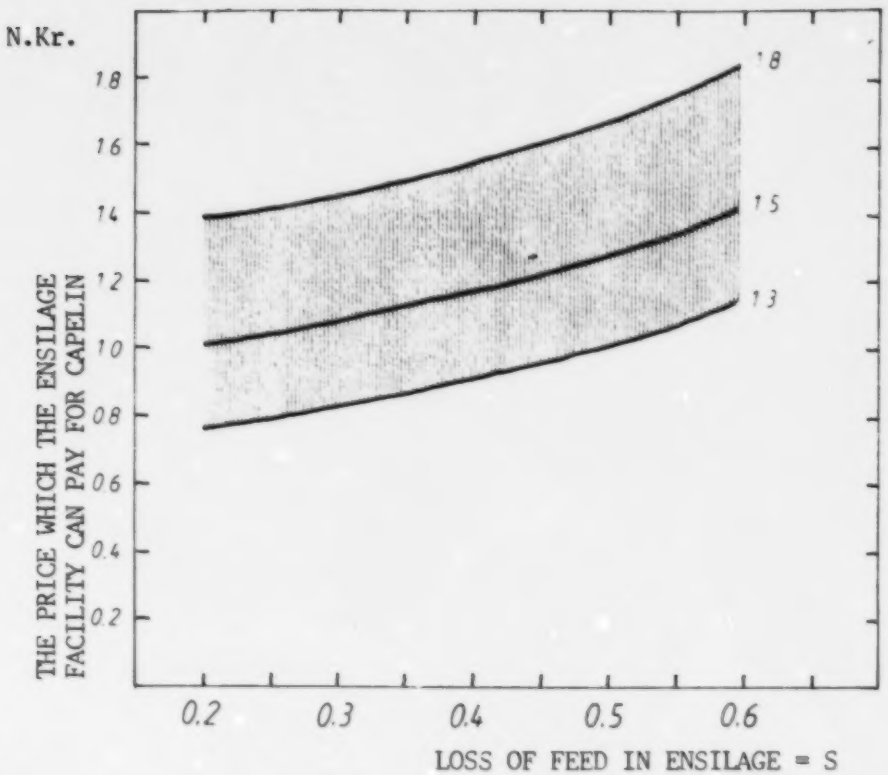

Fig. 14. The maximum price which the ensilage facility can pay for capelin for ensilation and heat treatment (B) when the fish farmer's loss of feed varies, when the loss of feed for wet feed is 8% higher than for acidic feed, and when the content of energy in capelin is 6.8 MJ OE per kg.

51 cont.

7.5.2 Variations in the Content of Energy in Capelin

It is assumed that there is a loss of feed of 48% for V and 40% for E, B, and M. It is further assumed that the content of energy in the binding agent constantly equals 12.6 MJ OE per kg (Skretting, 1983-84). The content of energy in capelin measured as MJ OE is indicated by x. The feed factor will

be as follows:

$$F_V = 13.5/(0.52(0.9x+1.26))$$

$$F_E = 13.5/(0.6(0.487x+6.3))$$ 52 cont.

$$F_B = 13.5/(0.6(0.828x+1.89))$$

$$F_M = 13.5/(0.6(0.830x+1.89))$$

If, in the equations for P, we insert for F the figures established in paragraph 7.5 as a function of the feed factor, we arrive at the price which the ensilage facility is willing to pay for capelin to be used for feed, at various contents of energy:

E: $$P_E = \frac{(13.5/(0.52(0.9x+1.26))(1036+1800p_V)+188}{974(13.5/(0,6(0.487x+6.3))} - 5.412$$

$$P_E = \frac{1.9x^2+(330.0+526.0p_V)x+6804.0p_V)+3950.6}{455.8x+638.2} - 5.412$$

B: $$P_B = \frac{(13.5/(0.52(0.9x+1.26))(609+1059p_V)-436}{974(13.5/(0.6(0.828x+1.89))} - 1.344$$ 53

$$P_B = \frac{-7.5x^2+(275.6+527.4p_V)x+1200.9p_V+666.6}{455.8x+638.2} - 1.344$$

M: $$P_M = \frac{(13.5/(0.52(0.9x+1.26))(609+1059p_V)-436}{977(13.5/(0.6(0.830x+1.89))} - 1.336$$

$$P_M = \frac{-7.5x^2+(275.6+527.4p_V)x+1200p_V+666.6}{457.2x+640.1} - 1.336$$

By inserting N.Kr. 1.80 as the upper limit and N.Kr. 1.30 as the lower limit, as well as the amount of N.Kr. 1.50 for P_V, we obtain the correlation between the content of energy in capelin and the price which the ensilage facility is willing to pay for capelin. This correlation is shown in Figures 16 to 18.

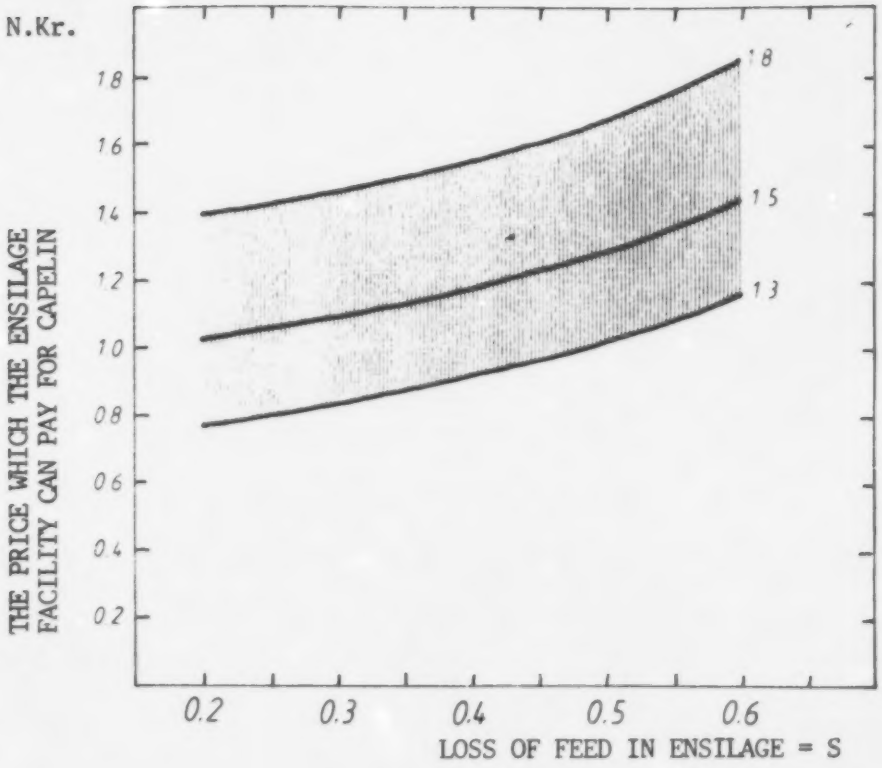

Fig. 15. The maximum price that the ensilage facility can pay for capelin to be used for heat treatment and lactic acid ensilation (M), when the fish farmer's loss of feed varies, when the loss of feed for wet feed is 8% higher than for acidic feed, and when the content of energy in capelin is 6.8 MJ OE per kg.

It is evident from Figures 16 to 18 that the lower the content of energy in capelin, the more the ensilage facility will be able to pay for capelin to be used for ensilage. The reason for this is the fact that the lower the content of energy, the more attractive ensilage is compared to frozen capelin with the same content of energy, and the more the fish farmer will be able to pay for ensilage. This is particularly evident in the case of E, where

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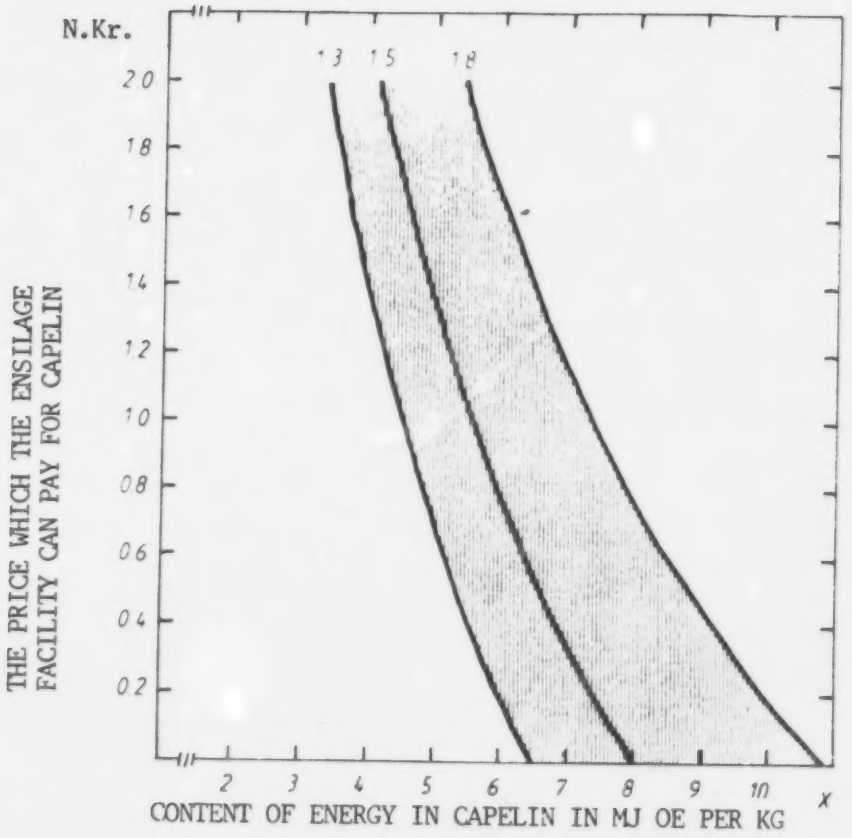

Fig. 16. The price which the ensilage facility is willing to pay for capelin tor be used for ensilage (E), when the loss of feed when using wet feed is 48% and 40% when using acidic feed, and when the content of energy in capelin varies.

even small changes in the content of energy will produce considerable changes in P_E. This tendency increases the lower P_V becomes. See Figure 16. In the case of B and M, the tendency is the same, only far weaker. All the same, the changes in P_B and P_M might be significant, even with small variations in x. See Figures 17 and 18. This will be discussed further in Paragraph 10.

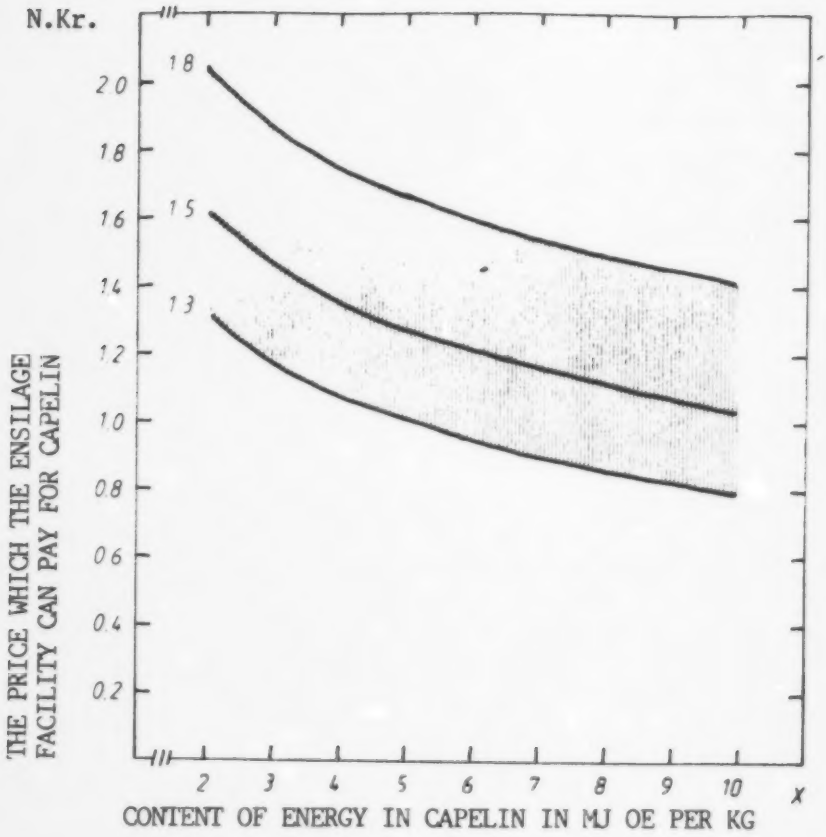

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Fig. 17. The price which an ensilage facility is willing to pay for capelin to be used for ensilation and heat treatment (B), when the loss of feed when using wet feed is 48% and 40% when using acidic feed, and when the content of energy in the capelin varies.

8 THE CURRENT VALUE METHOD

The current value method constitutes a way of evaluating the profitability of an investment. The following equation will be used to express the current

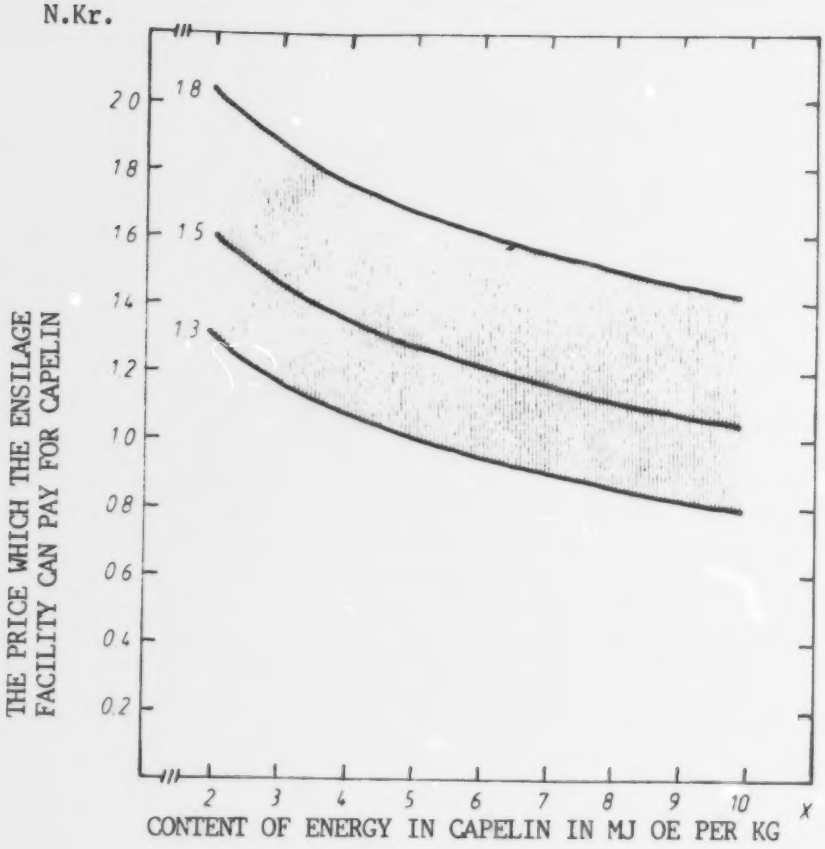


Fig. 18. The price which the ensilage facility is willing to pay for capelin to be used for heat-treatment and lactic acid ensilation (M), when the loss of feed when using wet feed is 48% and 40% when using acidic feed, and when the content of energy in the capelin varies.

56

value NNV) of the investment:

55 cont.

$$NV = -U_o + \sum_{t=1}^{n} \frac{I_t}{(1+k)^t} + \frac{S_n}{(1+k)^n} \quad \text{(Boye, 1979)}$$

The symbols mean: U_0 = the cost of the investment

n = the lifetime of the item invested in

S_n = selling value at the end of the lifetime of the item invested in 56 cont.

k = capital costs

I_t = balance in years (t) (the difference between receipts and disbursements owing to the investment) (Ibid.)

Compare Appendix 2.

In this case, the balance (surplus) equals the difference between the income from the sales and the expenses to be paid each year. In order for the investment to be profitable, the difference between the discounted receipts and disbursements has to be more than zero, or equal zero, i.e. NV=0, or NV>0 (Ibid.).

9 MAXIMUM INVESTMENT IN HEAT TREATMENT EQUIPMENT 57

As is evident from the above, an ensilage facility producing heat treated ensilage will be able to pay much more for fresh capelin to be used for ensilation than the market price, given the assumptions underlying my calculations. This means that, at "normal" prices on capelin, one will be able to invest a great deal more in heat treatment equipment than that which such equipment costs today.

9.1 ASSUMPTIONS

These calculations do not take into account the form of financing. This means

that any possible investment subsidy or possibility of DUF-sales have not been included in my analysis. Questions of taxation will not be discussed either.

When calculating the maximum amount which one can justify in terms of investing in heat treatment equipment, I base my calculations on the premise that the NV of the investment is zero. It is assumed that the facility will begin from scratch. It is not realistic to count on a sale of 10,200 tons of heat treated ensilage from the beginning. I assume that one may sell 2,000 tons the first year, 5,000 tons the second year, and 10,200 tons the third year and each following year for the entire lifetime of the facility. It is all an approximation.

The maximum price of heat treated ensilage will be that price at which the fish farmer is indifferent in his choice between heat treated ensilage (B and M) and non-heat treated ensilage (E). As is evident from the above, this price depends on the costs of producing wet feed from frozen capelin. The income from the sales will be:

First year: (2,000 x 1,553) = N.Kr. 3,106,000
Second year: (5,000 x 1,553) = N.Kr. 7,765,000
Third year: (10,200 x 1,553) = N.Kr.15,840,600

58

These figures are based on a price of N.Kr. 1.50 per kg of frozen capelin. I assume a depreciation (S_{Π}) to zero after 6⅔ years which results in annual write-offs of 15%. The requirement of interest payments has been set at k=13.5%.

9.2. INVESTMENTS

The cost of investment will be N.Kr. 3,173,500 + 1.1 U_B in the case of B.

U_B indicates the maximum investment in heat treatment equipment. In the case of M, the investment cost will be N.Kr. 2,940,300 + 1.1 U_M. See Table XXIII. The maximum investment (U_M) has to cover the heat treatment equipment/ lactic acid ensilation equipment as well the expenses required for tanks in addition to the amount of N.Kr. 1,024,000 which is sufficient for E and B.

9.3 ACCOUNTS PAYABLE/BALANCE (SURPLUS)

When the price of fresh capelin equals P and the production is 2,000 tons the first year, 5,000 tons the second year, and 10,200 tons the third year and the rest of the lifetime of the facility, the payable costs will be as follows:

Table 12. Accounts payable at the ensilage facility 59

	B			M		
	1st yr	2nd yr	3rd yr+	1st yr	2nd yr	3rd yr+
Capelin: $974P_B$ q=	$1948000P_B$	$4870000P_B$	$9934800P_B$	-	-	-
$977P_M$ q=	-	-	-	$1954000P_M$	$4885000P_M$	$9965400P_M$
Acid: (1540000/10200)q=	301961	754902	1540000	-	-	-
(541416/10200)q=	-	-	-	106160	265400	541416
Molasses: (382500/10200)q=	-	-	-	75000	187500	382500
Lactic acid bacteria: 70.3 q=	-	-	-	140600	351500	717060
Wages: (255883/10200)q=	50173	125433	255883	-	-	-
(255893/10200)q=	-	-	-	50175	125438	255893
Electr. equipm.: (287049/10200)q=	56284	140710	287049	-	-	-
(246674/10200)q=	-	-	-	48367	120919	246674
Maint./repair: $0.04\frac{3173500+1.1U_B}{10200}$ q=	24890+ $0.009U_B$	62225+ $0.022U_B$	126940+ $0.044U_B$	-	-	-
$0.04\frac{3173500+1.1U_M}{10200}$ q=	-	-	-	23061+ $0.009U_M$	57653+ $0.022U_M$	117612+ $0.044U_M$
Distribution: 100 q=	200000	500000	1020000	200000	500000	1020000
ACCOUNTS PAYABLE	$1948000P_B$+ 633308+ $0.009U_B$	$4870000P_B$+ 1583270+ $0.022U_B$	$9934800P_B$+ 3229872+ $0.044U_B$	$1954000P_M$+ 643363+ $0.009U_M$	$4885000P_M$+ 1608410+ $0.022U_M$	$9965400P_M$+ 3281155+ $0.044U_M$

The balance (surplus) (I_t) is arrived at by subtracting the payable costs from the revenues from sales. See Appendix 5.

9.4 MAXIMUM INVESTMENT IN HEAT TREATMENT EQUIPMENT

It is assumed that the price of capelin is N.Kr. 0.46 per kg. A 15% write-off rate on the equipment is assumed, i.e., a lifetime of $6\frac{2}{3}$ years.

With a write-off of 15%, the lifetime will be $6\frac{2}{3}$ years.

For the last $\frac{1}{3}$ of the year, the I_t will be as follows:

B: $I_t = 2/3 I_{3+} = 8406752 - 6623200P_B - 0.029U_M$

M: $I_t = 2/3 I_{3+} = 8372963 - 6643600P_M - 0.029U_M$

I equate NV=0 to the discounted surplus minus the costs of investment ment.

B: $0 = -3173500 - 1.1U_B + 39408674 - (31046827 \times 0.46) - 0.138U_B$

$\underline{U_B = 17733145}$.

When applying the principle of indifference, one may invest a total of N.Kr. 17.7 million in heat treatment equipment to be installed together with Hamjern's ensilation equipment.

60

M: $0 = -2940300 - 1.1U_M + 39248993 - (31142452 \times 0.46) - 0.138U_M$

$\underline{U_M = 17756999}$

When the fish farmer is indifferent in his choice, he can invest a maximum of N.Kr. 17.7 million in heat treatment and lactic acid ensilation facilities, including an additional investment in storage tanks. Assuming that the storage tanks cost approximately N.Kr. 1,394,000 according to Stord Bartz, the maximum amount which one can invest in the processing equipmnent itself will be N.Kr. 17,756,999 - (1,394,000-1,024,000) = N.Kr. 17,386,999.

9.5 VARIATIONS IN THE PRICE OF FRESH CAPELIN

I assume an amortization period of $6\frac{2}{3}$ years and a depreciation value $S_n = 0$ after the same amount of time. It is further assumed that the interest payments amount to 13.5%. Assuming that NV=0 and keeping P as a variable, we arrive at the following calculation:

$$B: \quad 0 = -3173500 - 1.1U_B + 39408674 - 31046827P_B - 0.138U_B$$

$$U_B = 29269123 - 25078212P_B$$

$$M: \quad 0 = -2940300 - 1.1U_M + 39248993 - 31142452P_M - 0.138U_M$$

$$U_M = 29328508 - 25155454P_M$$

In Figure 19, I plot the price of fresh capelin against the maximum investment in heat treatment equipment. The correlation is linear. Variations in the price of capelin will cause considerable changes in the maximum amount which can be invested in heat treatment equipment.

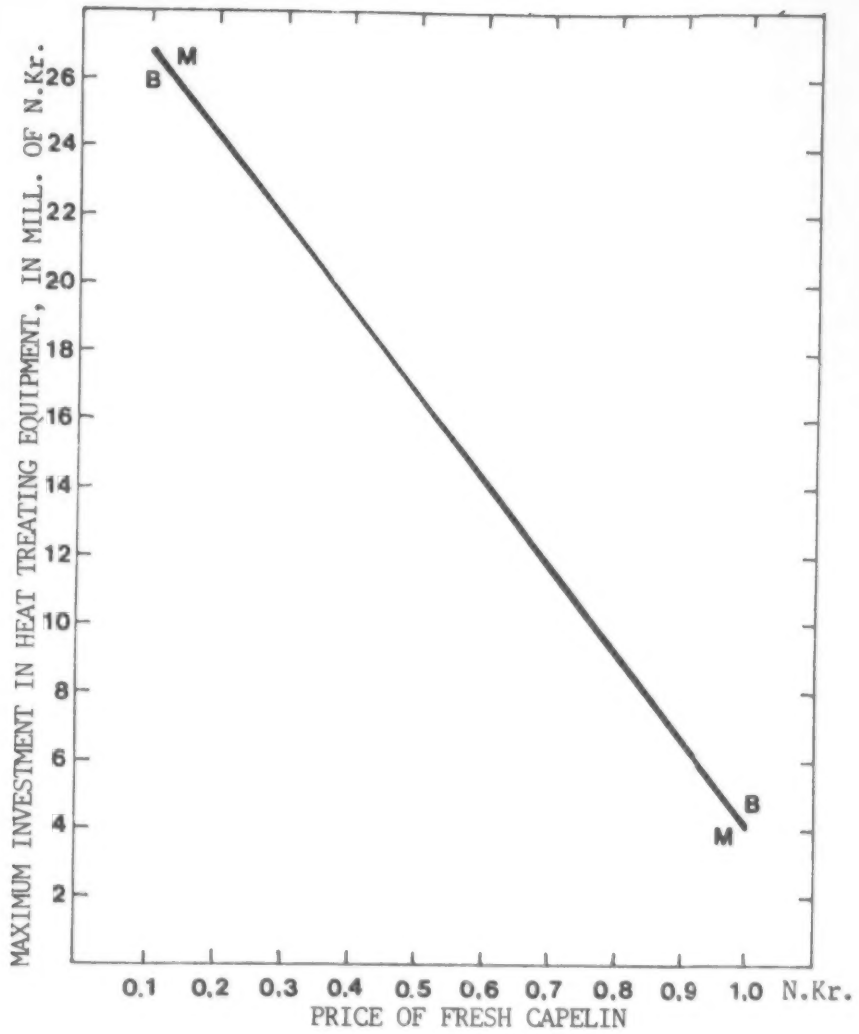


Fig. 19. The maximum amount to be invested in heat treatment equipment, when the price of capelin varies.

9.6 VARIATIONS IN THE SELLING PRICE OF HEAT TREATED ENSILAGE

It is assumed that the facility will sell 2,000 tons of ensilage the first year, 5,000 tons the second year, and 10,200 tons the third and following years of the lifetime of the facility. An amortization period of 6½ years

is assumed, as well as a depreciation of S_n=0 and interest payments of 13.5%. If the ensilage facility sells its product at a price which is lower than the maximum price of N.Kr. 1,553 per ton for both B and M, the balance (surplus) will change. It is assumed that fresh capelin costs N.Kr. 0.46 per kg. A calculation of the accounts payable and of the balance (surplus) is shown in Appendix 6. 62

The values which emergefor the surplus are inserted in the expression for NV, and when NV=0 the result is as follows:

$$B: \quad 0 = -3173500 - 1.1U_B + 31874p_B - 24375076 - 0.138U_M$$

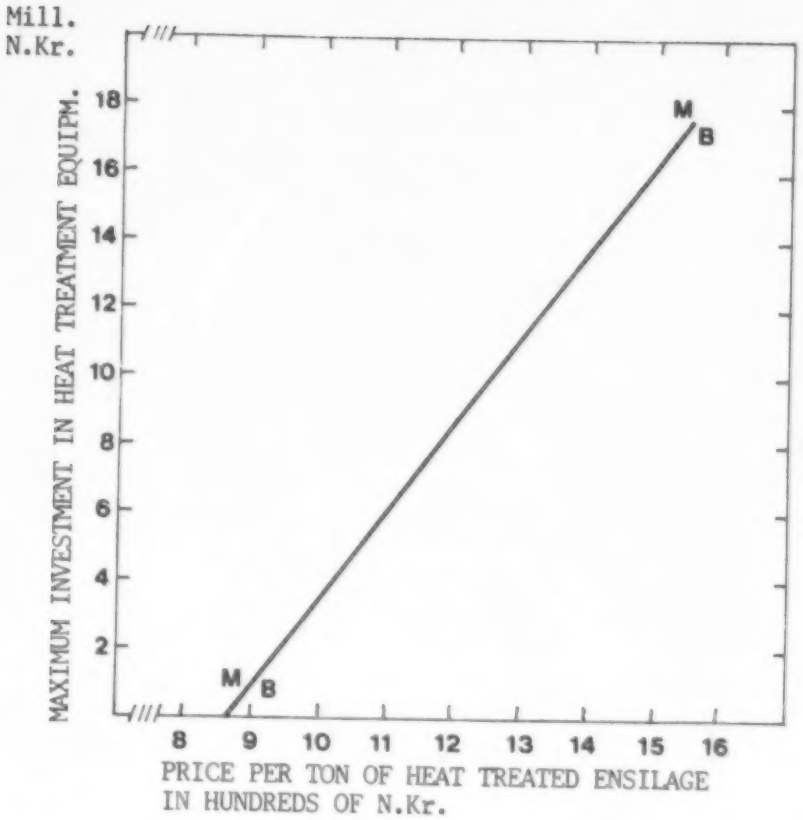
$$U_B = 25746p_B - 22252485$$

$$M: \quad 0 = -2940300 - 1.1U_M + 31874p_M - 24579328 - 0.138U_M$$

The selling price of ensilage is plotted against the maximum amount to be invested in heat treatment equipment. See Figure 20.
The correlation is linear. If the price of ensilage to the fish farmer is lowered, U_B and U_M are quickly reduced; however, even at a price of N.Kr. 1 per kg, one will be able to invest over N.Kr. 2 million in heat treatment equipment and still have a profitable investment.

9.7 VARIATIONS IN THE PERIOD OF AMORTIZATION 63

It is assumed that the facility sells 2,000 tons of ensilage the first year, 5,000 tons the second year, and 10,200 tons the third year of operation. After the third year it is assumed that the facility will go on selling



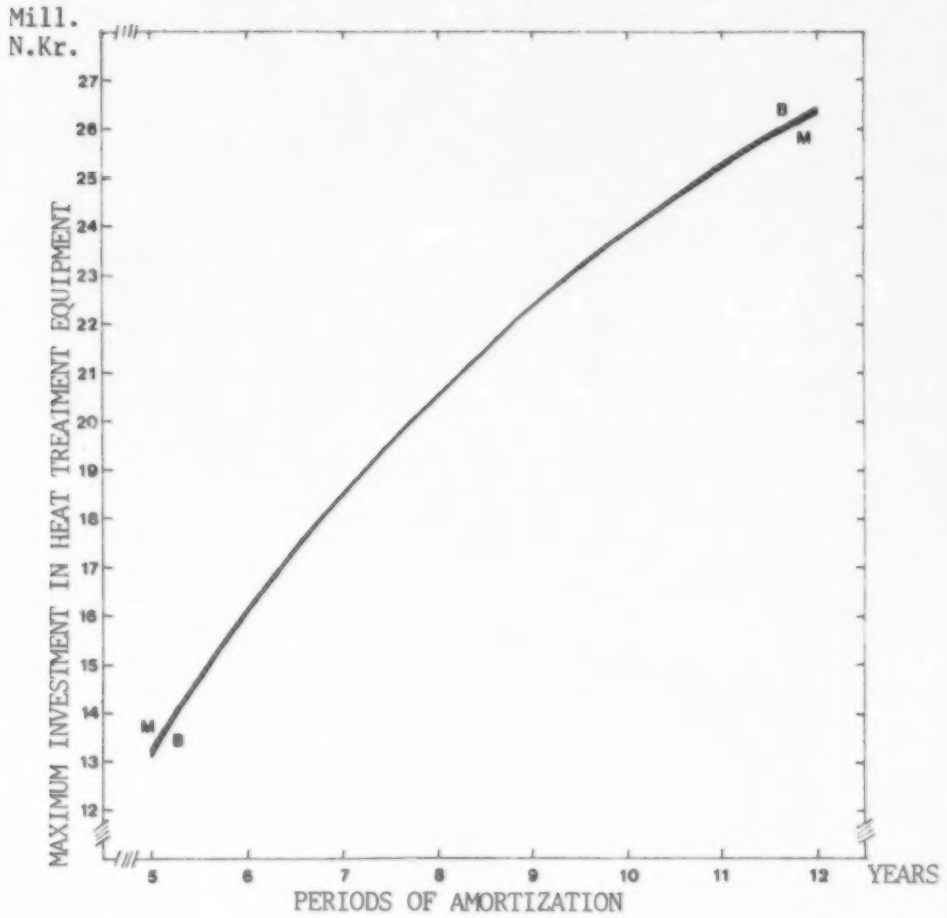
62 cont.

Fig. 20. The maximum amount to be invested in heat treatment equipment, when the price of finished ensilage varies below the maximum price.

10,200 tons annually. It is assumed that the asking price is the maximum price, i.e., the price at which the fish farmer is indifferent, i.e., N.Kr. 1,553 per ton of ensilage. It is further assumed that S_n=0 after 6 $\frac{3}{4}$years, and that the interest payments amount to 13.5%. It is also assumed that fresh capelin costs N.Kr. 0.46 per kg. This price is inserted in the equation for NV, and I have set NV=0. My calculations are based on periods of amortization from five to twelve years, i.e., on write-offs of from 20% to 8.3% annually. Appendix 7 shows the values arrived at for the various periods of amortization.

63 cont.

In Figure 21, the periods of amortization from five to twelve years have been plotted against the maximum investment in heat treatment equipment:



64

Fig. 21. The correlation between periods of amortization and the maximum amount to be invested in heat treatment equipment.

Even with a period of amortization of only five years, one will be able to invest up to approximately N.Kr. 13 million in heat treatment equipment and still have a profitable investment. The maximum amount of investment rapidly increases when the period of amortization is increased. However, this increase grows smaller with each period of amortization.

63 cont.

10 SUMMARY AND COMMENTS

10.1 MAXIMUM PRICE OF CAPELIN

In order to determine the maximum price which the fish farm can pay for capelin, I have included in my calculations all costs connected with the production of fish feed at the farming facilities and of ensilage at a centrally located ensilation facility. I have excluded buildings for the processing equipment and any other operations.

By using existing items available on the market and real prices, I have attempted to give as true a picture as possible of the costs involved in the investment and operation of both types of facilities determining the maximum price of capelin. Nevertheless, there is a great deal of uncertainty with respect to some of the components. During the editing process of this report, for example, Hamjern A/S went bankrupt. However, there were plans to continue the operation. I therefore decided to use the data obtained from Hamjern A/S unchanged. 64 cont.

With regard to the other items to be purchased, it would take considerable deviations in price for them to have any particular impact on the price which the ensilage facility will be willing to pay for capelin. The most significant element of uncertainty is, surely, the design of the tanks. Any variations in the fixed expenses will have the greatest impact on E, since E involves a lower level of production than B and M. As an alternative tank system for E, one might consider a storage capacity of 180 m^3. At a production level of 4,600 tons of ensilage per year, a storage capacity of 180 m^3 should be 65

of the same proportion in relation to the annual level of production, as would be 400 m^3 tanks at an annual production of 10,200 tons of heat treated ensilage. If we have a tank capacity of 180 m^3, we should take into account, in our calculations, an increased need to return the product to the intermediate storage tanks. When insulating 200 m^3 of the intermediate storage tanks, the investment costs for E will instead be N.Kr. 480,800. This would result in a total investment of N.Kr. 2,575,980, or rounded off N.Kr. 2,576,000, including investment tax. That is N.Kr. 84.0 per ton in write-offs and N.Kr. 37.8 per ton in annual interest payments, assuming that we use the rates discussed previously.

Maintenance and repair costs for the alternative tank system for E amount to N.Kr. 22.4.

The savings per ton of ensilage obtained by reducing the storage capacity to 180 m^3 and by insulating 200 m^3 of the intermediate storage tanks, will amount to the difference between the annual write-offs, annual interest payments, and the annual cost of maintenance and repairs, for storage capacities of 400 m^3 and 180 m^3 respectively:

Savings = (103.5+46.6+27.6) - (84.0+37.8+22.4) = N.Kr. 33.5

Savings per kg of capelin = ((33.5 x 0.974)/1,000) = N.Kr. 0.033

The difference between that which the fish farmer is willing to pay and the full cost of a 400 m^3 tank was only N.Kr. 0.021. See Paragraph 4.4. Consequently, the above change in the size of tank capacity would suffice to lower the full cost below that which the fish farmer is willing to pay. I have also

used a high estimate per litre of storage capacity. As mentioned previously, one would likely be able to build cheaper tanks, and it would appear that the prospects are good that one will be able to pay a price for capelin which is above the market price while, at the same time, operating with a profit.

If it should be possible to purchase acid at a price of N.Kr. 4 per kg, this would result in savings of (151-115) = N.Kr. 36 per ton of ensilage in the case of E and B, and savings of (53.1-43) = N.Kr. 10.1 per ton in the case of M, or as follows per kg of capelin:

E and B: $((36 \times 0.974)/1{,}000) = \underline{\text{N.Kr. } 0.035}$ 66

M: $((10.1 \times 0.977)/1{,}000) = \underline{\text{N.Kr. } 0.010}$

The difference is rather small. However, in the case of E, the savings are sufficient to obtain profitability.

As far as the other costs in connection with the ensilage facility are concerned, they were discussed in the report. The distribution costs and the level of production in the case of E, present the most significant elements of uncertainty. The way in which the problems have been presented shows that the costs in connection with the fish farming facility are of far greater significance in terms of the price which the ensilage facility can pay for capelin than are the costs in connection with the ensilage facility itself. This is due to the fact that it is the maximum price which the fish farmer is willing to pay, which determines the maximum selling price of capelin.

The amount of capelin required to produce one kg of salmon (mixed-in capelin multiplied by the feed factor) is the greatest in the case of V. Then follow B and M, whereas it takes far less capelin in the case of E. A change in the price per kg of capelin in V results in a change in the full cost figure which has to be distributed on a relatively small amount of ensilage in B and M, and especially in E, i.e., the change is considerable per unit of weight. This is the reason why the price becomes so significant in terms of that which the ensilage facility is able to pay for capelin, as shown in Paragraph 7.4.

There is a direct link between the feed factor and the loss of feed, when the content of energy is constant; and there is a direct link between the feed factor and the content of energy, when the loss of feed is constant. This is shown in Figures 22 and 23.
The feed factor increases with an increased loss of feed and a reduced content of energy in capelin.

When S varies, F_V changes somewhat more than the feed factors for the various types of acidic feed which have quite a similar graphic curve. This implies that when S increases, the costs that depend on the feed factor, including the full cost, increase somewhat more rapidly in the case of B, M, and E. When the principle of indifference is applied (the full cost of wet feed equals the full cost of acidic feed), there will be more left over for the purchase of ensilage than if the loss of feed were lower. As shown in Paragraph 7.5.1, the result is that the ensilage facility is able to pay more for capelin, the higher the loss of feed is at the fish farm.

67

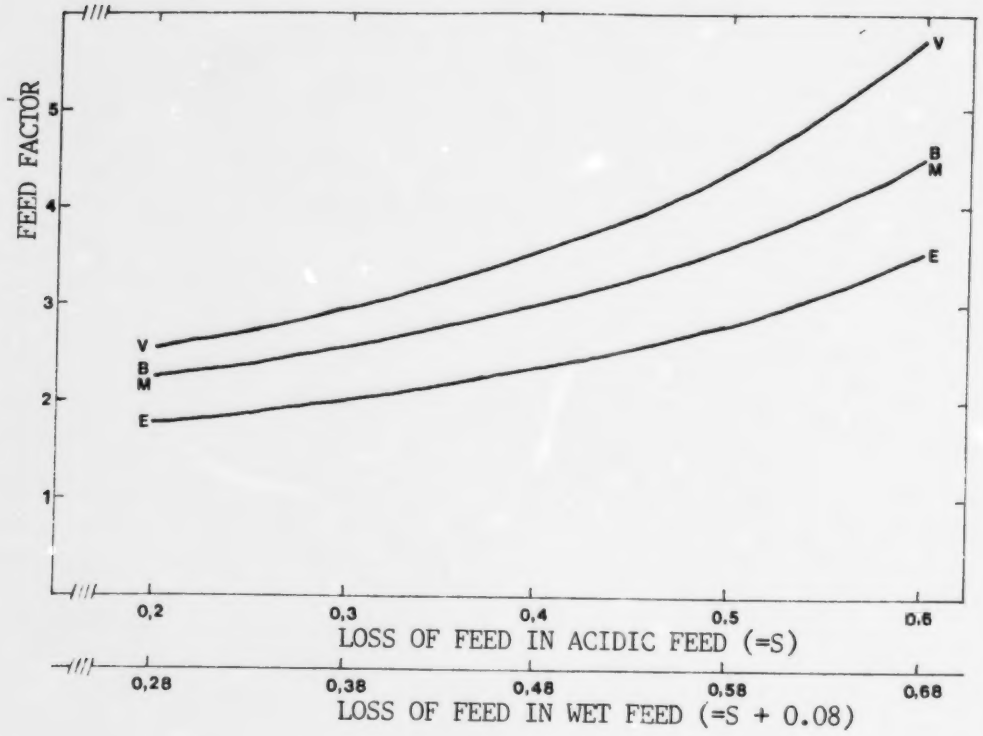


Fig. 22. The correlation of the feed factor with the loss of feed, when the content of energy is constant and equals 6.8 MJ OE per kg of capelin, and when the feed factor varies. The loss of feed in acidic feed =S; the loss of feed in wet feed = (S + 0.08).

In the case of the content of energy x in capelin, we have a similar situation, only here F_V varies considerably, F_B varies somewhat less, and F_E varies very little. When x is reduced, the cost of producing wet feed is increased relatively more than in the cases of E, B, and M. It is therefore possible to pay more for ensilage and heat treated ensilage without increasing the average total cost. The greater the difference in feed factor, the more one is able to afford, i.e., the price of E rises dramatically, whereas the the price of B and M rise less markedly. A direct consequence of this is that

the ensilage facility is able to pay more for capelin. See Figures 16 to 18. When we have high values for x, the role of the binding agent in terms of content of energy is less significant. The binding agent is very expensive per unit of energy, compared to capelin. The result is that the fish farmer can pay almost nothing at all for ensilage E which requires 50% of a binding agent. If x rises high enough, the fish farmer will pay more just for the binding agent than for both capelin and binding agent. In addition, he will 68
have the additional costs to contend with in connection with the production of wet feed. The result will be that he can pay nothing at all for ensilage. Consequently, the ensilage facility cannot pay anything either. See Figure 16.

Finally, it is worth mentioning the large quantities of capelin remains left over from the production of capelin roe and sold to the herring oil/fish meal plants for about N.Kr. 0.20 per kg. In Båtsfjord alone where there are four capelin roe producing plants, a total of approximately 15,500 tons of capelin remains went into the production of fish meal in 1982. That is more than the volume of production used in my calculations. Capelin remains constitute an important potential for raw material for ensilation which, in 69
terms of energy, is far more favourable than desiccation.

10.2 MAXIMUM INVESTMENT IN HEAT TREATMENT EQUIPMENT

As is evident from the above discussion, it is very profitable to invest in heat treatment equipment, seen from the perspective of the current value method. One can afford to invest much more than is required. The price of fresh capelin has to rise much higher than is realistically to be expected

68 cont.

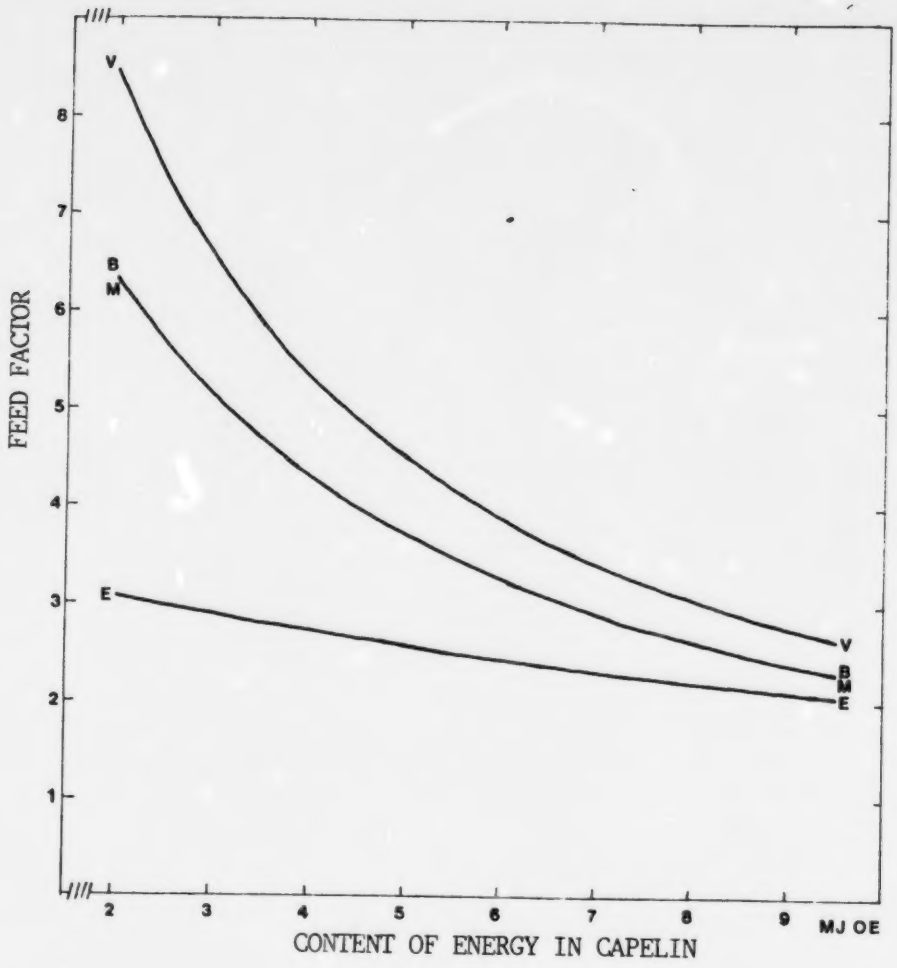


Fig. 23. The correlation of variations in the feed factor with the content of energy in capelin measured as transformable energy (MJ), when the loss of feed is 48% in the case of V and 40% in the case of E, B, and M.

if the investment is to become unprofitable, assuming that the maximum price will be charged for the heat treated ensilage. When we take the market price of fresh capelin as a given, the amount which can be invested in heat treatment equipment is higher than that which is presently required judging from the price of equipment currently on the market. This is so if ensilage is

69 cont.

sold at a price which is higher than approximately N.Kr. 0.90 per kg. A price should therefore be charged which is higher than this amount, but lower than the maximum price. The periods of amortization are of little significance if the other values are what I assumed them to be in my calculations. If other conditions which have an impact on the maximum price change, such as the price of frozen capelin, or the content of energy in capelin, such factors will have to be taken into account in the evaluation.

In my calculations, I assumed that it would be necessary to invest in new unloading facilities and tanks, i.e., the kind of investments required if one does not already have this type of equipment. The herring oil/fish meal plants have such equipment, and it would appear that for these plants, investments in ensilage equipment and heat treatment equipment would be even more profitable, provided that they have the capacity.This would require a special study since, in reality, these plants have the choice between two alternatives: fish meal or ensilage. All the same it would seem that the herring oil/fish meal industry ought to be the appropriate facilities for such investments.

As mentioned in the introduction, the ensilation process kills all bacteria, including the pathogenic ones. If the ensilage is heat treated, also viruses are killed (Raa, pers. com.). The risk of disease owing to the feed has thus been reduced to a bare minimum. This is an important factor, especially if one is aiming at exporting the product, for example to Finland, where there is a big market for animal fodder.

When evaluating alternative B against alternative M, the following should be taken into consideration: Heat treatment according to alternative B will result in a concentration of acid in the finished feed, and no experiments have been carried out, on a large scale, to determine whether the fish might react negatively to the feed (Ibid.). In the case of alternative M, the amount of acid is lower, and this particular problem (if it does indeed exist) may be avoided. 70

11 CONCLUSION

My calculations based on energy, took as their point of reference the growth of fish produced at fish farming facilities, and I draw the following conclusions:

A price which is clearly above the market price may be paid for capelin to be used for ensilation and heat treatment, when the capelin is sold to fish farmers who otherwise use frozen capelin for wet feed. Ordinarily, a price close to the market price can be paid for capelin which is to be ensilated but not heat treated. The costs in connection with an investment in tank facilities as well as the costs of distribution are both factors by which any change from that which was assumed in my calculations, will bring about considerable changes. With respect to ensilation without heat treatment, the level of production is also important. Of even more importance are, however, the costs at the fish farming facilities that are going to buy the ensilage. Here, the most important factors are the price of frozen capelin, the content of energy in capelin, and the loss of feed.

By using the current value method to determine the profitability of an investment, I have shown that it is indeed profitable to invest in heat treatment equipment. One is even able to pay more for heat treatment equipment than that which such equipment costs today. The sale of ensilage below the maximum price rapidly reduces the disposable income, as does the price of fresh capelin. The period of amortization does not play a significant role, unless the price of finished ensilage and of fresh capelin, combined or each separately, shows a most unfavourable development.

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13 TABLES

I

Table I. Total investments at the ensilage facility.

ITEMS TO BE PURCHASED	Total Investment E	B	M
Netzsch N150 mono-pump	250000	250000	250000
HMK 100-2 rotating measuring device	228000	228000	228000
Netzsch NES 150A pump	235000	235000	235000
Intermediate storage tanks, 600 m³	936000	936000	936000
Hamjern Processing Equipment	212000	212000	-
Land Techniques Flow-Therm Processing equipment	-	1315000	-
Stord Bartz Ltd. processing equipment	-	-	816000
Storage tank, 400 m³	1024000	1024000	1394000
Subtotal	2885000	4200000	3859000
10% investment tax	288500	420000	385900
Total investment	3173500	4620000	4244900

Table II. Annual write-offs and annual interest payments at the ensilage facility

	Total			Per ton of ensilage		
	E	B	M	E	B	M
Annual write-offs	476025	693000	636735	103.5	67.9	62.4
Annual interest paym.	214211	311850	286531	46.6	30.6	28.1

Table III. Annual expenses for maintenance and repairs at the ensilage facility.

		E	B	M
Annual expenses for maintenance and repairs	Total	126940	184800	169796
	Per ton	27.6	18.1	16.6

Table IV. Cost of electricity for ensilation process II

	E	B	M
Unloading facility	842	1874	1874
Processing equipment	4025	285175	244800
Total	4867	287049	246674
Per ton	1.1	28.1	24.2

Table V. Calculation of the full cost of producing ensilage (E), heat treated ensilage (B), and heat treated and lactic acid fermented ensilage (M), when the price of capelin equals the market price, and the cost of lactic acid bacteria equals m per ton of ensilage.

COSTS	TOTSL COSTS			COST PER UNIT		
	E	B	M	E	B	M
VARIABLE COSTS:						
Capelin	2060984	4570008	4584084	448.0	448.0	449.4
Acid	694600	1540000	541416	151.0	151.0	53.1
Molasses	-	-	382500	-	-	37.5
Lactic acid bacteria	-	-	m_T	-	-	m
Wages	35728	255883	255893	7.8	25.1	25.1
Electricity	4867	287049	246674	1.1	28.1	24.2
Maintenance/repairs	126940	184800	169796	27.6	18.1	16.6
Distribution	460000	1020000	1020000	100.0	100.0	100.0
SUM OF VARIABLE COSTS	3383119	7857740	7200363 $+m_T$	735.5	770.3	705.9 +m
FIXED EXPENSES						
Write-offs	476025	693000	636735	103.5	67.9	62.4
Interest payments	214211	311850	286531	46.6	30.6	28.1
SUM OF FIXED EXPENSES	690236	1004850	923266	150.1	98.5	90.5
FULL COST = TOTAL COSTS	4073355	8862590	8123629 $+m_T$	885.6	868.8	796.4 +m

Table VI. Storage capacity for frozen/ensiled capelin at the fish farm, when the capacity is correlated with the mixed-in binding agent, feed factor, and unusable space in the freezer room.

	3000 m^3	8000 m^3
E: Storage tank:	50 m^3	100 m^3
B: Storage tank:	100 m^3	200 m^3
M: Storage tank:	100 m^3	200 m^3
V: Freezer Room:	150 m^3	300 m^3

Table VII. Investments at the fish farms with respect to the production of feed from frozen capelin (V), ensilage (E), heat treated ensilage (B), and heat treated and lactic acid fermented ensilage (M), when the farming facilities have a capacity of 3,000 m^3 and 8,000 m^3 respectively. III

Equipm. purchased	3000 m^3				8000 m^3				
	V	E	B	M	V	E	B	M	
Freezer capacity 150/300 m^3	195000	-	-	-	315000	-	-	-	(Juliussen, pers. com.)
Crusher	22500	-	-	-	22500	-	-	-	(Eidnes, pers. com.)
Grinder Wolfking F-160	31000	-	-	-	31000	-	-	-	(Ibid.).
Storage tank @ NKr 1.56 a litre	-	78000	156000	156000	-	156000	312000	312000	(Myrland, pers. com.)
Insulation @ NKr 1.00 a litre	-	50000	100000	100000	-	100000	200000	200000	(Sketch -)
Pump	-	15000	15000	15000	-	15000	15000	15000	(Ibid.).
Pipes/cranes	-	20000	20000	20000	-	20000	20000	20000	(Ibid.).
Binding agent silo 25m^3 (In-door)	-	11200	-	-	-	11200	-	-	(Kjelsberg, pers. com.)
Screw/motor	-	3000	-	-	-	3000	-	-	(Ibid.).
Stand for silo	-	3000	-	-	-	3000	-	-	(Ibid.).
Peletization machine 1500/100 incl. safety plate	60500	60500	60500	60500	60500	60500	60500	60500	(Eidnes, pers. com.)
SUM OF INVESTMENTS	309000	240700	351500	351500	429000	368700	607500	607500	
10% shipping/installation	30900	24070	35150	35150	42900	36870	60750	60750	
SUM OF INVESTMENTS, installed	339900	264770	386650	386650	471900	405570	668250	668250	
10% investment tax	33990	26477	38665	38665	47190	40557	66825	66825	
TOTAL INVESTMENTS	373890	291247	425315	425315	519090	446127	735075	735075	

Table VIII. The basis for amortization in the case of freezer rooms (8% write-off per year), when the fish farms have a capacity of 3,000 m³ and 8,000 m³ respectively.

	3000 m^3	8000 m^3
Investment	195000	315000
10% shipping and installation	19500	31500
Subtotal	214500	346500
10% investment tax	21450	34650
Basis for amortization	235950	381150

Table IX. Annual write-offs at fish farming facilities.

	3000 m^3				8000 m^3			
	V	E	B	M	V	E	B	M
Freezer room 8%	18876	-	-	-	30492	-	-	-
Equipment 15%	20691	43687	63797	63797	20691	66919	110261	110261
Total	39567	43687	63797	63797	51183	66919	110261	110261
Per kg of salmon	0.659	0.728	1.063	1.063	0.320	0.418	0.689	0.689

Table X. Annual interest payments at fish farming facilities. IV

	3000 m^3				8000 m^3			
	V	E	B	M	V	E	B	M
Total	25238	19659	28709	28709	35039	30114	49618	49618
Per kg of salmon	0.421	0.328	0.478	0.478	0.219	0.188	0.310	0.310

Table XI. Annual cost of maintenance and repairs at fish farming facilities.

	3000 m^3				8000 m^3			
	V	E	B	M	V	E	B	M
Total	14956	11650	17013	17013	20764	17845	29403	29403
Per kg. of salmon	0,249	0.194	0.284	0.284	0.130	0.112	0.184	0.184

Table XII. Annual consumption of feed at fish farms. Various types of feed.

	3000 m^3	8000 m^3
V:	211.1 tonn	563.2 tonn
E:	140.4 tonn	374.4 tonn
B:	179.4 tonn	478.4 tonn
M:	179.4 tonn	478.4 tonn

Table XIII. The cost of a binding agent at fish farms. Various types of feed.

	Total		Per kg of salmon	
	3000 m^3	8000 m^3	3000 m^3	8000 m^3
V:	100320	267520	1.672	1.672
E:	333450	889200	5.558	5.558
B:	127823	340860	2.130	2.130
M:	127823	340860	2.130	2.130

Table XIV. The cost of producing feed at fish farms. Various types of capelin V based feed.

	Total		Per kg of salmon	
	3000 m^3	8000 m^3	3000 m^3	8000 m^3
V: (211.2/1,5 +1·360)55 kr=	27544		0.459	
(563.2/1.5 +1·360)55 kr=		40451		0.253
E: (140.4/1.5+0.5·360)55 kr=	15048		0.251	
(374.4/1,5+0.5·360)55 kr=		23628		0,148
B: (179.4/1.5+0.5·360)55 kr=	16478		0.275	
(478.4/1 5+0.5·360)55 kr=		27441		0.172
M: (179.4/1.5+0.5·360)55 kr=	16478		0.275	
(478.4/1.5+0,5·360)55 kr=		27441		0.172

kr = Norwegian kroner · = x (multiplication)

Table XV. The cost of electricity at ensilage facilities. Various types of capelin based feed.

		Total		Per kg of salmon	
		3000 m^3	8000 m^3	3000 m^3	8000 m^3
V: freezer room:	150 m^3: (360dg·24t·3kW·0,25kr)=	6480		0.108	
	300 m^3: (360dg·24t·6kW·0.25kr)=		12960		0.081
Equipment:	$\left(\frac{0.9\cdot15}{5.5}+\frac{0.9\cdot7.5}{2.5}+\frac{26}{1.5}+\frac{1.5}{3}\right)3.52\cdot60\cdot0.25=$	1214		0.020	
	$\left(\frac{0.9\cdot15}{5.5}+\frac{0.9\cdot7.5}{2,5}+\frac{26}{1.5}+\frac{1.5}{3}\right)3.52\cdot160\cdot0.25=$		3237		0.020
E: Equipment:	$\left(\frac{26}{1.5}+\frac{1.5}{3}+\frac{4\cdot0.5}{10}\right)2.34\cdot60\cdot0.25=$	633		0.011	
	$\left(\frac{26}{1.5}+\frac{1.5}{3}+\frac{4\cdot0.5}{10}\right)2.34\cdot160\cdot0.25=$		1688		0.011
B=M: Equipment:	$\left(\frac{26}{1.5}+\frac{1.5}{3}+\frac{4\cdot0.85}{10}\right)2.99\cdot60\cdot0.25=$	815		0.014	
	$\left(\frac{26}{1.5}+\frac{1.5}{3}+\frac{4\cdot0.85}{10}\right)2.99\cdot160\cdot0.25=$		2174		0.014

dg = days kW = kw

t = hours kr = Norw. kroner · = x (multiplication)

Table XVI. Costs for frozen capelin at fish farms, when the price of capelin is N.Kr. 1.50 per kg.

	Total	Per kg of salmon
3000 m^3: (1,50·60000·0,9·3,52)kr=	285120	4,752
8000 m^3: (1,50·160000·0,9·3,52)kr=	760320	4,752

· = x (multiplication)

Table XVII. Calculation of full cost of producing wet feed and acidic feed on fish farms, when the price of E, B, and M has been set in such a way that full cost V = full cost E = full cost B = full cost M (per kg of salmon). VI

COSTS	TOTAL COSTS						PER KG OF SALMON					
	3000 m^3			8000 m^3			3000 m^3			8000 m^3		
	V	E	B=M	V	E	B=M	V	E	B=M	V	E	B=M
VARIABLE COSTS												
Frozen capelin	285120	-	-	760320	-	-	4.752	-	-	4.752	-	-
Ensilage	-	76312	-	-	162080	-	-	1.270	-	-	1.012	
Heat treated ensilage	-	-	245804	-	-	631717	-	-	4.096	-	-	3.948
Binding agent	100320	333450	127823	267520	889200	340860	1.672	5.558	2.130	1.672	5.558	2.130
Maintenance/repairs	14956	11650	17013	20764	17845	29403	0.249	0.194	0.284	0.130	0.112	0.184
Wages	27544	15048	16478	40451	23628	27441	0.459	0.251	0.275	0.253	0,148	0.172
Electricity, equipment	1214	633	815	3237	1688	2174	0.020	0,011	0.014	0.020	0,011	0.014
SUM, VARIABLE COSTS	429154	437093	407933	1092292	1094441	1031595	7.152	7.284	6.799	6.827	6.841	6.448
FIXED EXPENSES												
Write-offs	39567	43687	63797	51183	66919	110261	0.659	0.728	1.063	0,320	0.418	0,689
Interest payments	25238	19659	28709	35039	30114	49618	0.421	0.328	0.478	0.219	0.188	0.310
Electricity, freezer rm	6480	-	-	12960	-	-	0.108	-	-	0.081	-	-
SUM, FIXED EXPENSES	71285	63346	92506	99182	97033	159879	1,188	1.056	1.541	0.620	0.606	0.999
FULL COST	500439	500439	500439	1191474	1191474	1191474	8.340	8.340	8.340	7.447	7.447	7.447

Table XVIII. The price which the fish farmer is willing to pay for ensilage and heat treated ensilage, when he is indifferent in his choice between ensilage and wet feed from frozen capelin, when frozen capelin costs N.Kr. 1.50 per kg.

	3000 m^3	8000 m^3
E: (1.270/0.5 2.34)kr=	1.085	
(1.012/0.5 2.34)kr=		0.865
B=M: (4.096/0.85 2.99)kr=	1.612	
(3.948/0.85 2.99)kr=		1.553

kr = Norwegian kroner

Table XIX. Calculation of full cost for ensilage facilities, when frozen capelin costs N.Kr. 1.50 per kg, when the selling price is the maximum price and equals the price at which the fish farmer is indifferent in his choice between frozen capelin for wet feed and ensilage for acidic feed. VII

	TOTAL COSTS			COSTS PER UNIT		
	E	B	M	E	B	M
VARIABLE COSTS						
Capelin, maximum price	1966040	11548440	12301200 $-m_T$	427.4	1132.2	1206.0-m
Acid	694600	1540000	541416	151.0	151.0	53.1
Molasses	-	-	382500	-	-	37.5
Lactic acid bacteria	-	-	m_T	-	-	m
Wages	35728	255883	255893	7.8	25.1	25.1
Consumption of electricity	4867	287049	246674	1.1	28.1	24.2
Maintenance/repairs	126940	184800	169796	27.6	18.1	16.6
Distribution	460000	1020000	1020000	100.0	100.0	100.0
SUM OF VARIABLE COSTS	3288175	14836172	14917479	714.9	1454.5	1462,5
FIXED EXPENSES						
Write-offs	476025	693000	636735	103.5	67.9	62,4
Interest payments	214211	311850	286531	46.6	30.6	28,1
SUM OF FIXED EXPENSES	690236	1004850	923266	150.1	98.5	90.5
FULL COST	3978411	15841022	15840745	865.0	1553.0	1553,0
PROFIT	0	0	0	0.0	0.0	0.0
MAXIMUM SELLING PRICE	3978411	15841022	15840745	865.0	1553.0	1553.0

Table XX. The cost of feed at the fish farm.

	TOTAL	PER KG OF SALMON
V:	$160000\ (p_V\ 0{,}9 + 4.75 \cdot 0.1) F_V$	$(p_v\ 0.9 + 4.75 \cdot 0.1) F_v$
E:	$160000\ (p_E\ 0{,}5 + 4.75 \cdot 0{,}5) F_E$	$(p_E\ 0.5 + 4.75 \cdot 0.5) F_E$
B:	$160000\ (p_B\ 0.85 + 4.75 \cdot 0.15) F_B$	$(p_B\ 0.85 + 4.75 \cdot 0.15) F_B$
M:	$160000\ (p_M\ 0.85 + 4.75 \cdot 0.15) F_M$	$(p_M\ 0.85 + 4.75 \cdot 0.15) F_M$

· = x (multiplication)

Table XXI. The cost of wages at the fish farm. VIII

V:	$(160/1.5\ F_V + 1 \cdot 360)\,55\text{kr} =$	$5867F_V + 19800$	$0.037F_V + 0.124$
E:	$(160/1.5\ F_E + 0.5 \cdot 360)\,55\text{kr} =$	$5867F_E + 9900$	$0.037F_E + 0.062$
B:	$(160/1.5\ F_B + 0.5 \cdot 360)\,55\text{kr} =$	$5867F_B + 9900$	$0.037F_B + 0.062$
M:	$(160/1.5\ F_M + 0.5 \cdot 360)\,55\text{kr} =$	$5867F_M + 9900$	$0.037F_M + 0.062$

· = x (multiplication) kr = Norwegian kroner

Table XXII. Consumption of electricity for the equipment at the fish farm.

	TOTAL	PER KG OF SALMON
V:	$\left(\frac{0.9 \cdot 15}{5.5} + \frac{0.9 \cdot 7.5}{2.5} + \frac{26}{1.5} + \frac{1.5}{3}\right) 160 \cdot 0.25\ F_V =$	$920F_V$	$0.006F_V$
E:	$\left(\frac{26}{1.5} + \frac{1.5}{3} + \frac{4 \cdot 0.5}{10}\right) 160 \cdot 0.25\ F_E =$	$721F_E$	$0.005F_E$
B:	$\left(\frac{26}{1.5} + \frac{1.5}{3} + \frac{4 \cdot 0.85}{10}\right) 160 \cdot 0.25\ F_B =$	$721F_B$	$0.005F_B$
M:	$\left(\frac{26}{1.5} + \frac{1.5}{3} + \frac{4 \cdot 0.85}{10}\right) 160 \cdot 0.25\ F_M =$	$721F_M$	$0.005F_M$

· = x (multiplication)

Table XXIII. Investments at the ensilage facility. U = heat treatment equipment.

INVESTMENTS	B	M
Netzsch N150	250000	250000
HMK 100-2	228000	228000
Netzsch NES 150A	235000	235000
Intermediate storage tanks	936000	936000
Hamjern processing equipment	212000	-
Flow-Therm processing equipm. or equiv.	U_B	-
Storage tank, 400m³	1024000	1024000
Stord Bartz proces. equipm. or equiv.	-	U_M
Additional tanks for M	-	
SUBTOTAL	$2885000+U_B$	$2673000+U_M$
10% investment tax	$288500+0.1U_B$	$267300+0.1U_M$
COST OF INVESTMENT U_o	$3173500+1.1U_B$	$2940300+1.1U_M$

14 APPENDIX

IX

APPENDIX 1 THE CONTENT OF ENERGY IN CAPELIN.

The content of energy in capelin all year round:

	Ton	Fat	Protein
1978: Winter	7888438	9.3%	15.2-1.9%
Summer Barents Sea /Jan Mayen	5185550	17.5%	13.8-1.9%
1979: Winter	5358921	9.7%	14.9-1.9%
Summer Barents Sea /Jan Mayen	5956880	17.6%	13.3-1.9%
1980: Winter	5340992	10.6%	14.8-1.9%
Summer Barents Sea	4559215	20.9%	13.4-1.9%
Summer Jan Mayen	1223729	21.0%	13.6-1.9%
1981: Winter	7837894	11.5%	14.8-1.9%
Summer Barents Sea	4540831	17.3%	13.7-1.9%
Summer Jan Mayen	914394	17.5%	14.1-1.9%
1982: Winter	5052336	12.1%	14.8-1.9%
Summer Barents Sea /Jan Mayen	5907129	19.4%	13.4-1.9%
Sum	60716309		
Average		14,43%	12,34%

APPENDIX 2. LIST OF SYMBOLS. X

AFC Fixed unit costs.

AVC Variable unit costs.

ATC Total unit costs = full cost per unit.

B Ensiled and heat treated capelin or acidic feed made from capelin with 15% binding agent.

D Distribution costs per ton of ensilage.

E Usually non-heat treated ensilage or acidic feed made from this ensilage with 50% binding agent.

F Feed factor = the quantity of feed required to produce 1 kg of fish at a fish farming facility.

I_t Balance (surplus) in years (t) (the difference between receipts and disbursements owing to the investments)

k Capital costs.

M Heat treated and lactic acid fermented capelin or acidic feed made from this capelin with 15% binding agent.

m Cost of lactic acid bacteria per ton of ensilage.

MJ OE Transformable energy expressed in Mega Joule.

n Lifetime of the equipment purchased.

NV Current value of an investment. Is calculated as shown in Paragraph 8.

P The maximum price which the ensilage facility is willing to pay for one kg of fresh capelin.

p Price of one kg of capelin/capelin ensilage for the fish farmer.

π Profit in percentages. XI

q Annual production of ensilage, measured in tons.

S Loss of feed in the case of acidic feed, expressed in percentages and with decimals (the loss of feed in the case of wet feed will then be (S + 0.08)).

S_n The selling value of the equipment invested in at the end of the lifetime of these items.

U Investment expenses. Is used as a parameter of the maximum investment in heat treatment equipment.

V Frozen capelin or wet feed made from this capelin with 10% binding agent.

x Content of energy in capelin, measured in MJ OE.

y Content of energy in finished feed, measured in MJ OE.

APPENDIX 3. STORD BARTZ A/S HEAT TREATMENT AND LACTIC ACID ENSILAGE FACILITY XII

Price advertized (total)		N.Kr. 1,546,000
- Intermediate storage tank		N.Kr. 30,000
- Shipping/installation of intermediate storage tank (estimate)		N.Kr. 3,000
- 2 storage tanks	N.kr. 600,000	
- Shipping of 2 storage tanks	N.Kr. 10,000	
- Insulation casing	N.Kr. 31,000	
- Installation (difference betw. 3 and 1 tons facilities)	N.Kr. 56,000	N.Kr. 697,000
- Processing equipment for a 3 ton facility, approximately		N.Kr. 816,000

APPENDIX 4. THE PRICE WHICH THE ENSILAGE FACILITY CAN PAY FOR FRESH CAPELIN FOR ENSILATION AS A FUNCTION OF THE PRICE OF FROZEN CAPELIN. XIII

The cost of capelin at an 8,000 m³ fish farm, when using various types of capelin ensilage and frozen capelin as feed, expressed as P_V, P_E, P_B, and P_M:

		TOTAL	PER KG OF SALMON
V:	$(p_V \; 160000 \cdot 0.9 \cdot 3.52)$kr=	$506880p_V$	$3.168p_V$
E:	$(p_E \; 160000 \cdot 0.5 \cdot 2.34)$kr=	$187200p_E$	$1.170p_E$
B:	$(p_B \; 160000 \cdot 0.85 \cdot 2.99)$kr=	$406640p_B$	$2.542p_B$
M:	$(p_M \; 160000 \cdot 0.85 \cdot 2.99)$kr=	$406640p_M$	$2.542p_M$

kr = Norwegian kroner · = x (multiplication)

The full cost per kg of salmon will then be N.Kr.:

$$V: \; (7.447 - 4.752 + 3.168p_V)\text{kr} = (2.695 + 3.168p_V)\text{kr}$$

$$E: \; (7.447 - 1.012 + 1.170p_E)\text{kr} = (6.435 + 1.170p_E)\text{kr}$$

$$B{=}M: \; (7.447 - 3.948 + 2.542p_{B/M})\text{kr} = (3.499 + 2.542p_{B/M})\text{kr}$$

kr = Norwegian kroner

In order for the fish farmer to be indifferent in his choice of feed, the full cost of producing feed from ensilage must equal the full cost of V. In this way, we will obtain the price which the fish farmer is willing to pay for ensilage by means of P_V:

$$E: \; 6.435 + 1.170p_E = 2.695 + 3.168p_V$$

$$p_E = \frac{3.168p_V - 3.740}{1.170} \quad \text{That is} \quad \frac{3168p_V - 3740}{1.170} \text{ N.Kr. per ton}$$

$$B{=}M: \; 3.499 + 2.542p_{B/M} = 2.695 + 3.168p_V$$

$$p_{B/M} = \frac{3.168p_V - 0.804}{2.542} \quad \text{That is} \quad \frac{3168p_V - 804}{2.542} \text{ N.Kr. per ton}$$

The amount which the fish farmer is willing to pay (P_V) is equated with the full cost at the ensilage facility, expressed by P_E, P_B, and P_M. In this way we arrive at the maximum price which the ensilage facility is willing to pay for capelin, expressed through the price of frozen capelin. See paragraph 7.4.

APPENDIX 5. SURPLUS XIV

The surplus (I_t) constitutes the difference between the income from sales and the accounts payable.

B: 1st year:
$$I_1 = 3106000 - 1948000P_B - 633308 - 0.009U_B$$
$$I_1 = 2472692 - 1948000P_B - o.009U_B$$

2nd year:
$$I_2 = 7765000 - 4870000P_B - 1583270 - 0.022U_B$$
$$I_2 = 6181730 - 4870000P_B - 0.022U_B$$

3rd year+:
$$I_{3+} = 15840000 - 9934800P_B - 3229872 - 0.044U_M$$
$$I_{3+} = 12610128 - 9934800P_B - 0.044U_B$$

M: 1st year:
$$I_1 = 3106000 - 1954000P_M - 643363 - 0.009U_M$$
$$I_1 = 2462637 - 1954000P_M - 0.009U_M$$

2nd year:
$$I_2 = 7765000 - 4885000P_M - 1608410 - 0.022U_M$$
$$I_2 = 6156590 - 4885000P_M - 0.022U_M$$

3rd year+:
$$I_{3+} = 15840600 - 9965400P_M - 3281155 - 0.044U_M$$
$$I_{3+} = 12559445 - 9965400P_M - 0.044U_M$$

APPENDIX 6. ACCOUNTS PAYABLE AND SURPLUS AT VARIATIONS IN THE SELLING PRICE OF HEAT TREATED ENSILAGE XV

The accounts payable are the following:

B:	1st year:	$1529388+0.009U_B$
	2nd year:	$3823470+0.022U_B$
	3rd year+:	$7799880+0.044U_B$
	Last $\frac{1}{3}$ of a year:	$5199920+0.029U_B$
M:	1st year:	$1542203+0.009U_M$
	2nd year:	$3855510+0.022U_M$
	3rd year+:	$7865239+0.044U_M$
	Last $\frac{1}{3}$ of a year:	$5243493+0.029U_M$

The surplus will be as follows:

B: $I_1 = 2000p_B-1529388-0.009U_B$

$I_2 = 5000p_B-3823470-0.022U_B$

$I_{3+} = 10200p_B-7799880-0.044U_B$

$I_{2/3} = 6800p_B-5199920-0.029U_B$

M: $I_1 = 2000p_M-1542203-0.009U_M$

$I_2 = 5000p_M-3855510-0.022U_M$

$I_{3+} = 10200p_M-7865239-0.044U_M$

$I_{2/3} = 6800p_M-5243493-0.029U_M$

The above values are incorporated in the equation for NV. See Paragraph 9.6.

APPENDIX 7. ENVESTMENT EXPENSES FOR HEAT TREATMENT EQUIPMENT AT VARIOUS PERIODS OF AMORTIZATION. XVII

The investment expenses will be as follows:

B: 5 years:
$0 = -3173500-1.1U_B+29895848-(23552435 \cdot 0.46)-0.105U_B$
$U_B = 13185251$

6 years:
$0 = -3173500-1.1U_B+35794666-(28199556 \cdot 0.46)-0.126U_B$
$U_B = 16027219$

7 years:
$0 = -3173500-1.1U_B+40991862-(32293936 \cdot 0.46)-0.144U_B$
$U_B = 18459125$

8 years:
$0 = -3173500-1.1U_B+45570890-(35901319 \cdot 0.46)-0.160U_B$
$U_B = 20541891$

9 years:
$0 = -3173500-1.1U_B+49605276-(39079630 \cdot 0.46)-0.174U_B$
$U_B = 22335280$

10 years:
$0 = -3173500-1.1U_B+53159801-(41879904 \cdot 0.46)-0.186U_B$
$U_B = 23889226$

11 years:
$0 = -3173500-1.1U_B+56331541-(44347106 \cdot 0.46)-0.197U_B$
$U_B = 25257033$

12 years:
$0 = -3173500-1.1U_B+59090783-(46520852 \cdot 0.46)-0.207U_B$
$U_B = 26409863$

M: 5 years:
$0 = -2940300-1.1U_M+29774680-(23624977 \cdot 0.46)-0.105U_M$
$U_M = 13250532$

6 years:
$0 = -2940300-1.1U_M+35649510-(28286411 \cdot 0.46)-0.126U_M$
$U_M = 16066444$

7 years:
$0 = -2940300-1.1U_M+40825571-(32393402 \cdot 0.46)-0.144U_M$
$U_M = 18476130$

8 years:
$0 = -2940300-1.1U_M+45385978-(36011896 \cdot 0.46)-0.160U_M$
$U_M = 20539846$

9 years:
$0 = -2940300-1.1U_M+49403957-(39199966 \cdot 0.46)-0.174U_M$
$U_M = 22316855$

10 years:
$0 = -2940300-1.1U_M+52944027-(42008895 \cdot 0.46)-0.186U_M$
$U_M = 23856637$

11 years:
$0 = -2940300-1.1U_M+56063031-(44483696 \cdot 0.46)-0.197U_M$
$U_M = 25181365$

12 years:
$0 = -2940300-1.1U_M+58811052-(46664137 \cdot 0.46)-0.207U_M$
$U_M = 26323832$

$\cdot$ = x (multiplication)

The assumptions behind these calculations are shown in the text. See Paragraph 9.7.